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OUTLINES
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Part
II

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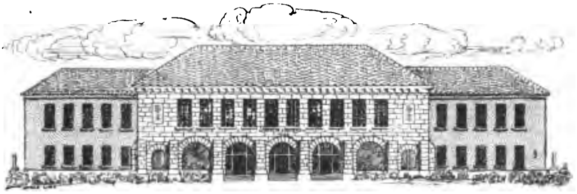

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OUTLINES

OF

INDUSTRIAL DRAWING

An Elementary Manual for the Self-Instruction of
Pupils of Public and Private Schools.

BY

PAUL A. GARIN,

Principal of Drawing in the Public Schools of Oakland, Cal.

PART II.

GRAMMAR COURSE.

FREE HAND AND INSTRUMENTAL.

W. B. HARDY,
961 Broadway, Oakland, Cal.
1892.

DEPARTMENT OF EDUCATION
LELAND STANFORD JUNIOR UNIVERSITY

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PREFACE.

Pupils *should* have a *Text-Book in Drawing* as they have in language, arithmetic, geography, etc.

1. To understand clearly the exact meaning and force of the printed word is one of the most essential things in language-study. This power may be acquired in different ways, one of which is to allow the pupil himself to study and execute from the printed directions.

2. In ungraded schools, a part of the class, working upon this plan, may practice drawing while other divisions are busy at other kinds of school work.

3. For reviewing term work.

4. New pupils, and those absent from school on account of sickness or other causes, will be able to make up their lost lessons without extra labor by the teacher, or loss of time by the class.

5. Another consideration is the use a pupil may make of this manual after he has left school: a copy book is generally torn up or thrown away, while a text-book is often kept as a reference book for a whole family.

Usually, industrial drawing books are more comprehensive than this one. They contain what *should be done:* this book covers only what *can be done* with the time and means now at our disposal in the public schools.

Perspective, historical ornament, etc., have been relegated to the High School, where they properly belong.

Constructive drawing for mechanics and farmers has been preferred to *pretty* and *showy* work, but the few sections on "Drawing from Natural Forms" have been inserted at the solicitation of some teachers who wish their pupils to have directions for sketching botanical and entomological objects.

For many valuable suggestions received from recent books on drawing, the author considers himself much indebted to contemporary writers.

P. A. G.

MATERIALS NEEDED.

Chapter I. 1. A soft pencil for free hand work. 2. A hard pencil for instrumental work. 3. A **straight** ruler. 4. A triangle: 45, 45, and 90 degrees. 5. Another large cardboard triangle for work at the blackboard. 6. A piece of VERY FINE sand or emery paper to finish sharpening the pencil. 7. A blank drawing book, or else sheets of Manilla or other paper, to be tied together, at the end of the school term. 8. A 12″ x 18″ sheet of heavy Manilla paper for model making.

Chapter II. Add to the above, a pair of compasses provided with pencil, ink, and steel points.

Chapter III. Add a draughtsman's scale.

Chapter IV and following. Add a protractor.

Pupils having remnants of wall paper, printed cloth, etc., should bring them to school to form a collection, or to show to the class.

The different steps in the execution of an example are designated in both text and corresponding figure by letters (a) (b) (c), etc.

Abbreviations: ′ means *foot* or *feet*; ″ means *inch* or *inches*; < > means *to* or *from*.

CHAPTER I.

SECTION 1.

INSTRUMENTAL DRAWING. RULER AND TRIANGLE.

General Directions.

1. Pencils and all marking instruments should be held with the **right hand.** Rulers, triangles, etc. with the **left hand.**

2. Lines should be **dark** enough to be plainly seen, but should **not be coarse** (broad).

3. Erasing wrong lines is allowed.

(*a*) An eraser should be **dry** and **clean.** If soiled, rub it upon a piece of rough paper until it becomes clean.

(*b*) Use. Rub **lightly;** hold the paper so that it will not crease; move the rubber in one direction only.

4. No free hand lines permitted in instrumental work.

5. In instrumental drawing, **let the work at the blackboard always precede that at the desk.**

TRIANGLE. There are two kinds of triangles in general use: one with angles of 45, 45, and 90 degrees, and the other with angles of 30, 60, and 90 degrees.

TWO DRILLS.

Write 1, 2, and 3 upon the different sides of the triangle, as shown in fig. 1.

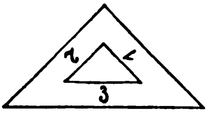


Fig. 1.

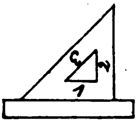


Fig. 2.

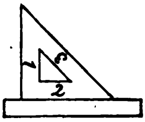


Fig. 3.

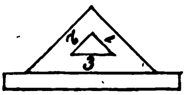


Fig. 4.

FIRST DRILL. Place side 1 of the triangle, close against the ruler, fig. 2. Change to side 2, fig. 3. Change to side 3, fig. 4.

Caution. In changing from one side to another, **do not lift the Triangle from the black-board or paper;** but, keeping both instruments FLAT upon the board or paper, turn the triangle about as shown in figures 5, 6, and 7.

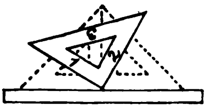


Fig. 5.

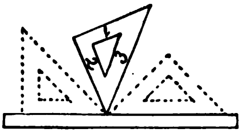


Fig. 6.

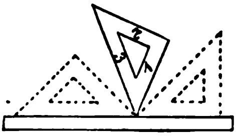


Fig. 7.

Fig. 5. Changing from side 1 to side 2, or from 2 to 1.
Fig. 6. Changing from side 2 to side 3, or from 3 to 2.
Fig. 7. Changing from side 3 to side 1, or from 1 to 3.

SECOND DRILL. Moving the **ruler and triangle together** place them in the following positions:

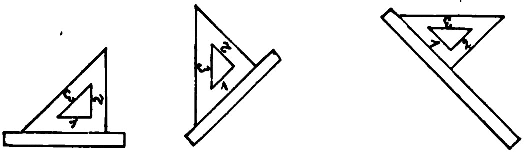


Fig. 8. Triangle on side 1.

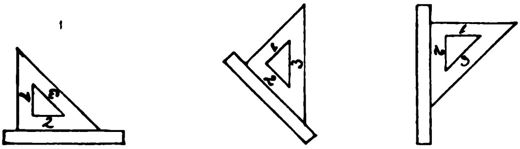


Fig. 9. Triangle on side 2.

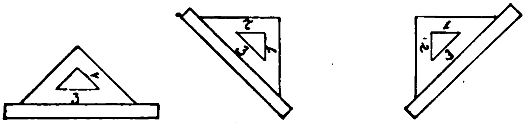


Fig. 10. Triangle on side 3.

SECTION 2.

RULER AND TRIANGLE. PARALLEL LINES.

The ruler and triangle are used:—

1. To draw **parallel** lines.
2. To draw **perpendicular** lines.

3. To **divide** lines **into** *equal* parts.

Problem 1. With ruler and triangle, to draw lines parallel to a given line, A B.

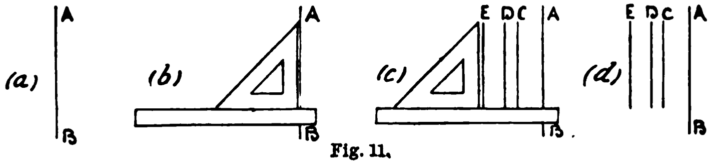


Fig. 11.

(*a*) Rule the given line A B.

(*b*) **Moving both instruments together,** place side 2 of the triangle close to line A B.

(*c*) **Without moving the ruler, slide** the triangle to the left (keep it always close to the ruler). Draw lines C, D, E.

(*d*) Instruments removed:.

Should the ruler slip from its position, replace both instruments close to line A B, as in (b) figure 11.

Never move the Ruler until the parallel lines are all drawn.

Practice until you are familiar with the instruments.

EXERCISES.

To draw lines parallel to:—

(1) A vertical line.

(2) A horizontal line.

(3) An oblique line (from the upper left to the lower right).

(4) An oblique line (from the upper right to the lower left).

Use successively sides 1, 2 and 3 of the triangle, placing the instruments as shown in the next figures. Use the ruler alone in drawing line A B; then, moving the ruler and triangle together, place one side of the triangle close to the line A B, etc.

Triangle on side 1.

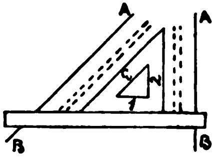


Fig. 12.

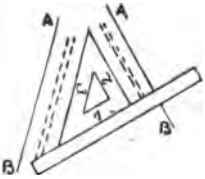


Fig. 13.

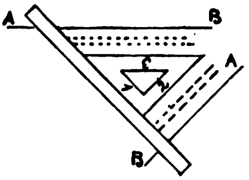


Fig. 14.

Triangle on side 2.

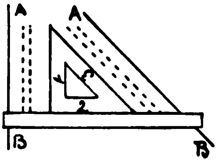


Fig. 15.

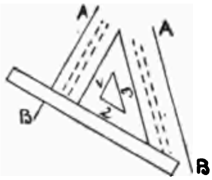


Fig. 13.

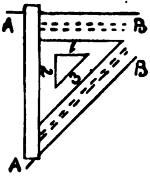


Fig. 17.

Triangle on side 3.

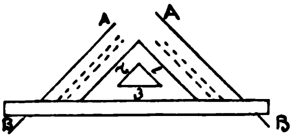


Fig. 18.

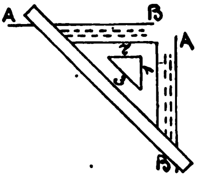


Fig. 19.

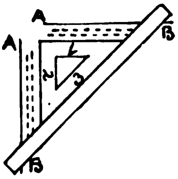


Fig. 20.

In the Book: According to the size of the blank-book, divide the first page into 2, 4 or 6 equal parts. In one of them draw problem 1.

—— SECTION 3. ——

RULER AND TRIANGLE. PERPENDICULAR LINES.

Problem 2. To erect lines perpendicular to a given line.

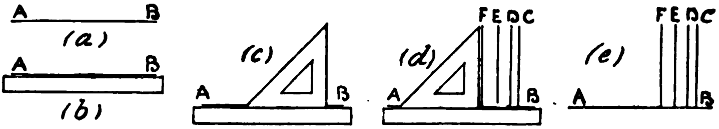


Fig. 21.

(*a*) Draw the given line A B.
(*b*) Lay the ruler close to A B.
(*c*) Place one of the sides of the triangle close against the ruler.
(*d*) Draw perpendicular lines C, D, etc.
(*e*) Instruments removed.

Caution. For perpendicular lines, remember to place first the ruler close to the given line, then, put the triangle in the proper position against the ruler.

EXERCISES.

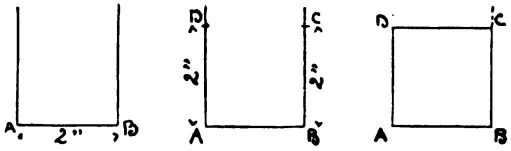
To draw lines perpendicular to:—

(1) A vertical line.
(2) A horizontal line.
(3) An oblique line (from the upper left to the lower right).
(4) An oblique line (from the upper right to the lower left).

Use in succession, sides 1, 2, and 3 of the triangle.

Problem 3. To construct a square upon a given base.

Base 2″ long.



(a) (b) (c)

Fig. 22.

(*a*) Draw base A B. With ruler and triangle, erect perpendicular lines (any length) at A and B.

(*b*) Draw points C and D, each two inches above A and B.

(*c*) Connect D C.

Problem 4. To construct an oblong of given dimensions.

Dimensions 2″ x 3″.

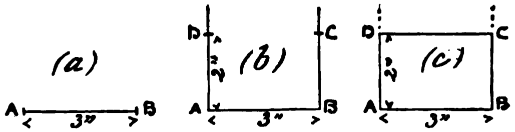


Fig. 23.

(*a*) Rule base A B, 3″ long.

(*b*) Erect perpendicular lines at A and B. Set off points C and D, each 2″ above the base.

(*c*) Connect D C.

Problem 5. To find the center of a square;—an oblong;—a rhombus;—a rhomboid.

Answer. Draw their diagonals, which will cross in the center of those figures.

In the Book: Draw several of the foregoing examples in different positions.

SECTION 4.

RULER AND TRIANGLE. DIVISIONS OF THE SQUARE, OBLONG, AND RHOMBS.

Problem 6. With ruler and triangle, to divide a square into four equal squares;—into 16 equal squares.

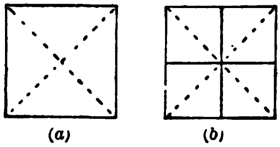
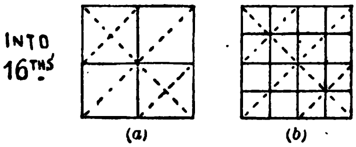

(a) (b)

Fig. 24.



(a) (b)

Fig. 25.

Problem 7. To divide a given oblong into four equal oblongs, all similar to the given oblong;—into 16 equal oblongs, all etc.

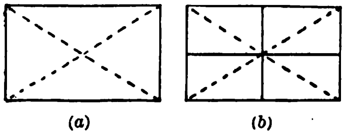
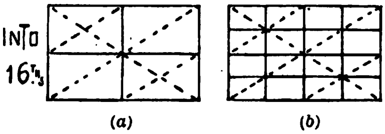

(a) (b)

Fig. 26.

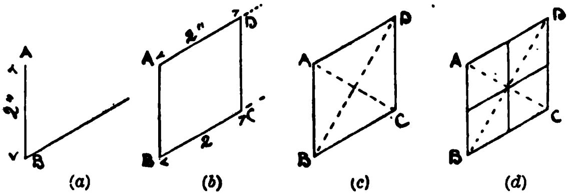


(a) (b)

Fig 27.

Problem 8. To divide a rhombus into four (or 16) equal rhombuses, all similar to the whole figure.

Sides 2″ each; any angles.



(a) (b) (c) (d)

Fig. 28.

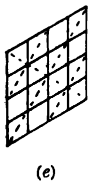

(e)

Fig. 29.

(*a*) Rule vertical line A B (2″ long), and an oblique line at B, making **any angle** with A B.

(*b*) Draw oblique line A D, parallel with B C. Set off 2″ from A to D, and 2″ from B to C. Connect D C.

(*c*) Find the center of the rhombus.

(*d*) Through the center, draw lines parallel to the sides of the rhombus.

(*e*) Divide each fourth into four other equal and similar parts.

EXERCISES.

In the same manner:—

1. Divide a rhomboid (sides 2″ x 3″ respectively) into four (or 16) equal rhomboids, all similar to the original figure.

2. Draw:

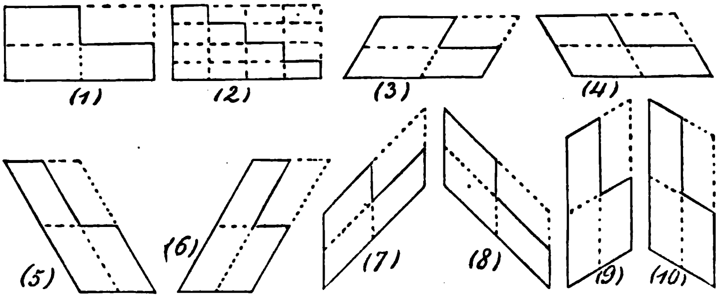


Fig. 30.

3. To inscribe a rhombus within a given oblong;—a rhomboid within a given rhomboid.

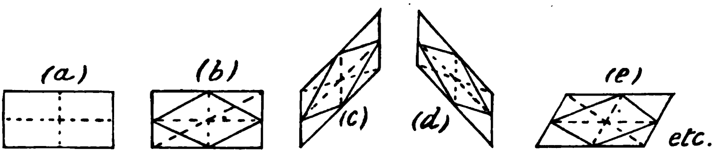


Fig. 31.

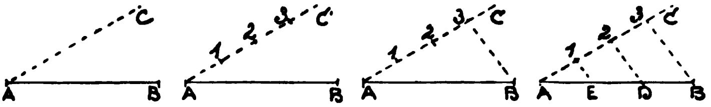
In the Book: With instruments, draw specimens of problems 6, 7, 8, and one of the exercises.

SECTION 5.

RULER AND TRIANGLE. DIVISION OF LINES AND PARALLELOGRAMS.

Problem 9. To divide a given line into any number of equal parts.

Into 3ds., for instance:—



(a) (b) (c) (d)

Fig. 32.

(*a*) Rule line A B, any length. Mark each end of the line with a small cross line. From A, draw line A C, making **any angle** with A B.

(*b*) From A, set off upon A C **any length** (¼", ½", ¾", etc.) three times. Make these divisions exactly **equal.**

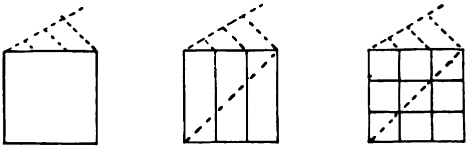
(*c*) Connect points 3 and B.

(*d*) With ruler and triangle, draw lines 2 D and 1 E, **parallel** to 3 B.

EXERCISES.

1. To divide into 5ths. a horizontal line 3" long.
2. To divide into 7ths. a vertical line 2¼" long.
3. To divide into 5ths. oblique lines 2¾", or any other length.

Problem 10. With ruler and triangle, to divide a square into nine equal squares.



(a) (b) (c)

Fig. 33.

(*a*) Construct the given square and divide one of its sides into 3ds. (Prob. 9).

(*b*) Draw vertical lines parallel with the sides of the square. Draw diagonal.

(*c*) At the intersections of the vertical lines with the diagonal, draw lines parallel with the upper side of the square.

Be accurate; have your pencil point sharp, if you wish to have equal squares.

Problem 11. To divide a square into 25 equal squares, with ruler and triangle.

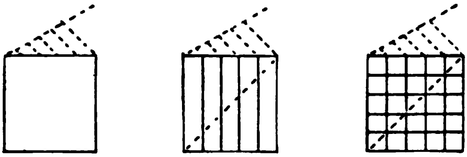

(a) (b) (c)

Fig. 34.

Problem 12. To divide a given oblong into nine equal oblongs, all similar to the given oblong.

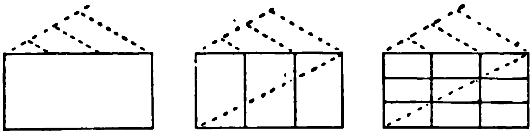

(a) (b) (c)

Fig. 35.

EXERCISES.

1. To divide an oblong (2" x 3½") into 25 equal oblongs, all similar to the given oblong.

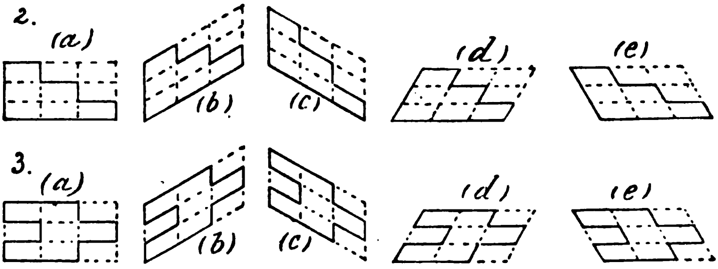


Fig. 36.

In the Book: With ruler and triangle, draw a sample of each problem in this section. Change the positions and sizes of the figures.

—— SECTION 6. ——

MAKING MODELS. TWO STEPS.

Models **must** be used in the drawing of solids. If you cannot make or procure them, **do not lose your time** in attempting to draw them by simply copying printed sketches.

As far as practicable, models should be home-made.

The making of models with soft wood, soap, clay, putty and similar materials requires so little ingenuity, that no special explanation is needed.

PAPER MODELS are more difficult to make, but are invaluable in learning how to cover the surfaces of solids, not only with cloth or paper, but also with metal sheets, as brass, tin, zinc, etc.

For paper models:—Use Manilla paper 24″ x 36″ inches, weighing 80 lbs. to the ream, or, according to size, its equivalent in weight. Paste with liquid glue.

SKELETON MODELS are easily made:—1st. of cork or of soaked peas, with wooden tooth picks or wire; 2nd, of cardboard and twine.

Do not make all models of paper; use a variety of materials, such as soaked peas and tooth picks, cardboard and twine, soap, soft wood, clay, putty, etc.

PRISMS.

A prism is a solid whose **two ends** or **bases** are similar, equal, and parallel plane figures, and whose **sides** or **lateral faces** are parallelograms.

Prisms of different forms are often named from the figure of their bases, as a triangular prism, a square prism, an oblong prism, etc., ((*a*) (*b*) (*c*) fig. 37).

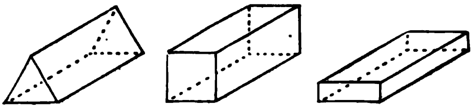

(a) (b) (c)

Fig. 37.

The cube is a prism having six equal square faces. The cylinder is a prism with an infinite number of sides.

BASES OF PRISMS.

There is an endless variety of forms used for bases of prisms.

Figure 38 shows how new bases are obtained by dividing squares and oblongs into fourths, ninths, etc.

GENERAL METHOD FOR MAKING PAPER PRISMS.

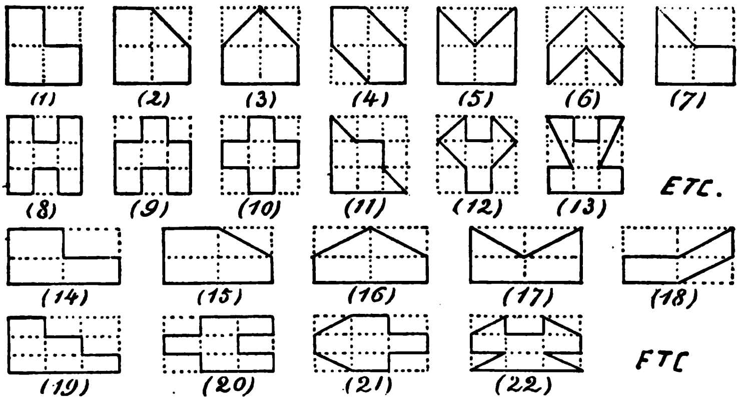


Fig. 38.

(*a*) Take the Two Steps; place the bases or ends **right** and **left.**

(*b*) and (*c*). Begin at the back of the steps, imagine that the lateral faces of the prism are unfolding until they are flat upon the table or desk.

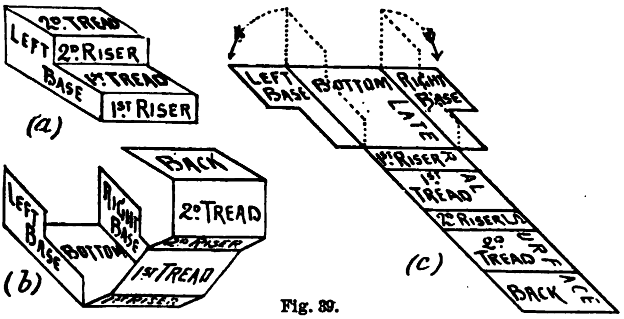


Fig. 39.

This unfolding shows that the length of covering required for the lateral faces equals the length of the *perimeter* of either of the bases.

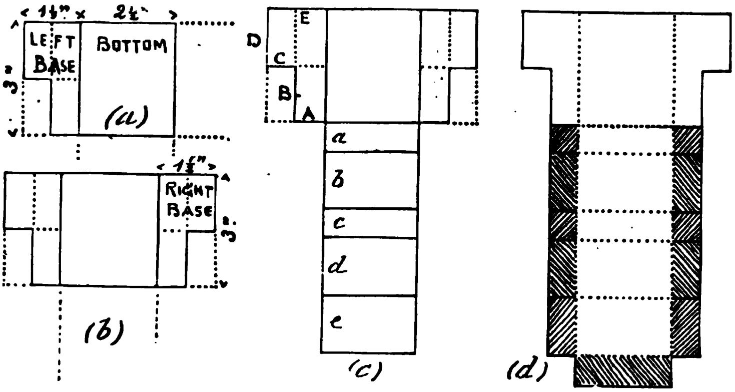


Fig. 40.

(*a*) Draw left base, and one of its lateral faces for the bottom of the solid.

(*b*) Add right base reversed. Extend the lines for the lateral surface.

(*c*) Let *a* equal A, *b* equal B, *c* equal C, *d* equal D, *e* equal E; in other words, let lengths *a*, *b*, *c*, *d*, *e*, equal lengths, A, B, C, D, E.

(*d*) For pasting, add extra surfaces at the lower end, and on each side of the pattern.

Fold the paper on the dotted lines, cut it on the full lines. Put the shaded surfaces inside of the model. **Leave the operation lines** (pencil marks) **on the outside**; they show how the model has been worked out, and will be of use in drawing it.

Sharp edges are obtained by cutting slightly with a pin, or a very hard pencil, the surface of the paper, on the dotted lines.

PASTING. Pupils should keep their hands and their models **clean.**

Begin always by pasting the shaded strip of paper which is at the bottom of the diagram ((d) fig. 40.); then the shaded strips on the sides, and finally the **ends** or **bases** of the model.

When the paper is too thick, it may be necessary to reduce the size and cut off the corners of the faces that are to be folded in.

NOTE. All the models should be put into a box and kept for use during this and the following terms.

In the Book: (Optional). Make the Two Steps of colored paper. Copy (*c*) of fig. 40.

Paste only the bottom of the model to the blank-book, in such a manner that the prism may be set up whenever wanted.

SECTION 7.

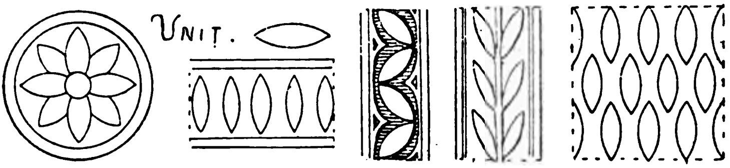
DECORATION.

REPETITION OF UNITS. SMALL BORDERS.

By examining carefully a carpet, a piece of wall-paper, etc., we notice that those patterns are made by repeating certain forms a number of times.

These forms are called **units.** They may be dots, lines, flowers, or combinations of dots, lines, flowers, etc.,

Units are repeated:—



(*a*) (*b*) (*c*) (*d*) (*e*)

Fig. 41.

1. Around a center (Rosettes), (*a*).
2. Along a line: horizontally, vertically, obliquely, (Bands and Borders), (*b*) and (*c*).
3. On both sides of a line, called *bi-symmetry*, (Borders, Finials, etc.,) (*d*).
4. To cover a surface, (All over patterns), (*e*).

EXERCISES.

On paper, slate, or blackboard, free-hand and very rapidly, enlarge a few of the following borders:

Notice. A number in parenthesis refers to a former example from which the present one is made; for instance, 3 (1) means that example 3 below is made from example 1:

Units: Parallel lines.

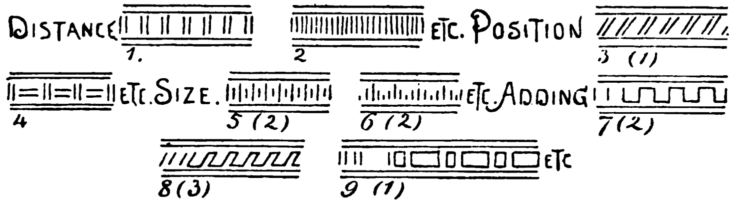


Fig. 42.

Units: Two Lines making **one angle.**

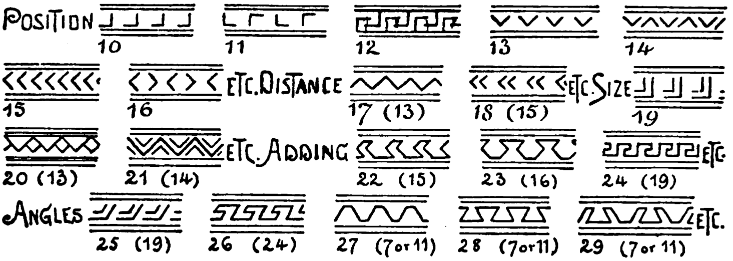


Fig. 43.

Units: Three lines.

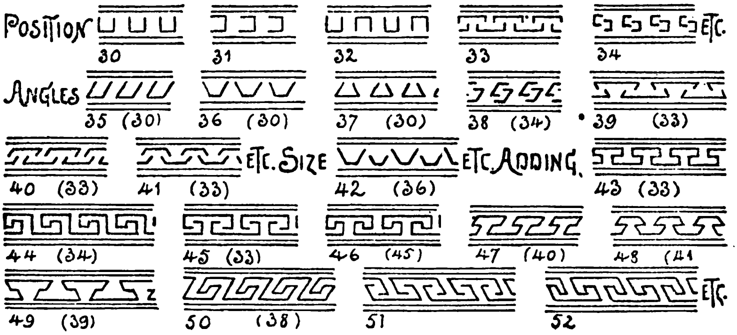


Fig. 44.

In the Book: 1. With pen and ink, or a soft pencil, make several borders similar to those above; or:

2. With instruments, draw one of the following Greek frets:

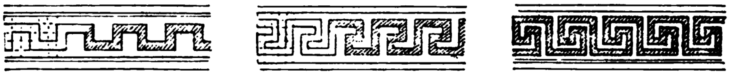


Fig. 45.

SECTION 8.

PAPER MODEL OF A DESK-SHAPED PRISM.

Follow the directions given in Section 6. Base equals 1½″ x 3″; distance between bases 2½″.

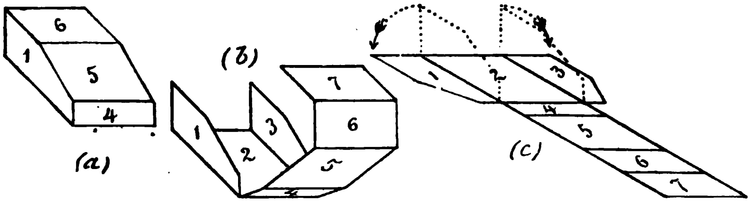


Fig. 46.

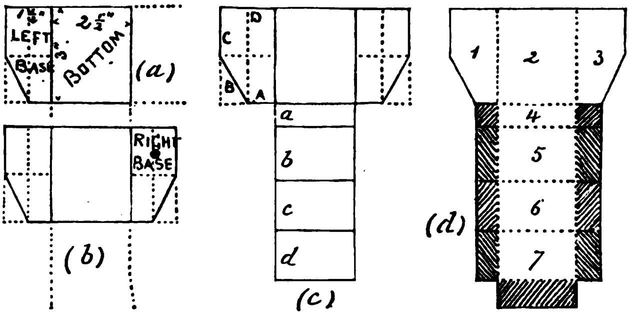


Fig. 47.

In (*c*), face *b* is obtained like the others, by transferring the lengths B to *b* on the lateral surface.

In the Book: (Optional). Work out this model as the Two Steps, Section 6.

SECTION 9.

SKELETON MODELS. (GENERAL METHOD.)

1. **Peas and tooth picks,** or pieces of cork and wire.

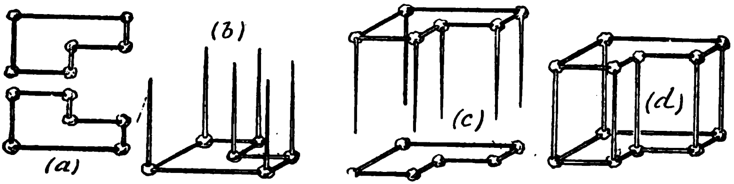


Fig. 48.

(*a*) Make the two bases.

(*b*) Insert perpendicularly a tooth pick in each corner of one of the bases lying flat upon the desk.

(*c*) and (*d*). Turn (*b*) over, and insert the other ends of the tooth picks into the peas in the corresponding corners of the second base.

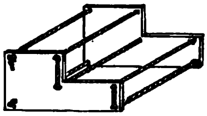


Fig. 49.

2. **Cardboard and twine.** Cut two equal cardboard bases. Make small holes as close as possible to the corners. Insert the twine as shown in figure 49.

Work in the same manner the **Desk-shaped Prism.**

Peas and tooth picks. Cardboard and twine.

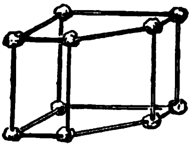


Fig. 50.

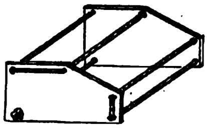


Fig. 51.

SECTION 10.

REVIEW OF OBLIQUE PROJECTIONS.* STATIONS. BASES OF PRISMS FACING FRONT AND REAR.

NOTE:—In this book, the word "**position**" means the **manner** in which a thing is **placed,** and "**station**" means the **spot** upon which the thing **stands.**

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* There are two methods for drawing an oblique projection:

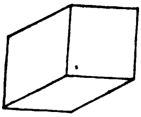


Fig. 1.

The first method consists in giving each line, even an oblique line, its regular size. This causes the object, a cube for instance, to appear a little longer than it actually is, fig. 1. To correct this effect, another method is often used. It consists in foreshortening the oblique lines, as follows:

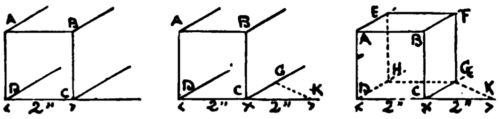


Fig. 2.

(*a*) Draw front, A B C D, 2″ square.

Add parallel oblique lines, any length.

(*b*) Draw the real length of oblique lines from C to K; then, line K G at any angle *less* than 45 degrees with base line D C K.

Models for this lesson:—A cube, the Two Steps, and the Desk-shaped Prism. Do not work **without the proper models in the hands of each pupil.**

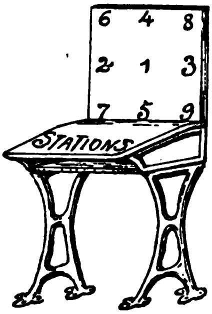


Fig. 52.

Imagine that there is a square board standing vertically upon the farther end of the top of your desk, fig. 52.

The numbers upon the board indicate the different places or **stations** where the model to be drawn should be held up.

Station 1 is directly opposite your sight; stations 2 and 3 are on a level with 1; 4 is above and 5 below 1; stations 6 and 7, 8 and 9 are in the corners of the imaginary board.

Stations 6, 7, 8, and 9 (giving more complete views of the model), are used oftener than the others.

The six faces of a cube may be called:

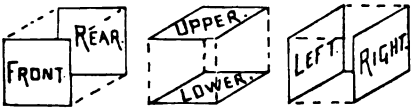


Fig. 53.

Hold the cube successively at the different stations, keeping four of its faces vertically, and its front parallelly to the board.

The model should always be held at arm's length.

(c) Draw lines of the rear, parallel to those of the front; G F parallel to B C, F E to A B, etc.

The first method has been used with the model placed at stations 6, 7, 8, and 9; the second method, when at stations 2, 3, 4, and 5. This was done to avoid the confusion resulting from two contiguous equal squares, fig. 3, either one of which may be taken for the front of the solid.

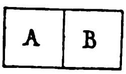


Fig. 3.

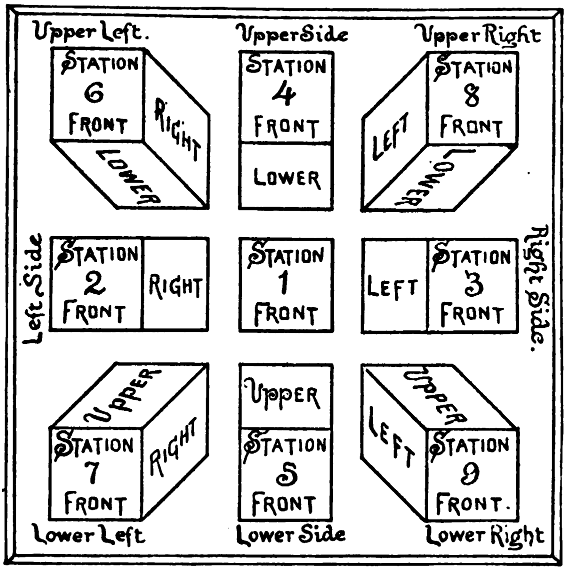


Fig. 54.

PRACTICE.

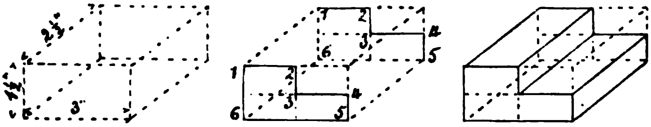
Move your cube from station to station until you know by heart and can name promptly the faces seen at each station.

Free hand and instrumental.

FIRST METHOD FOR DRAWING PRISMS.

Imagine that the Prism is to be cut from a block.

Place the block at station 7, in the position shown in (*c*) fig. 55.



(*a*) (*b*) (*c*)

Fig. 55.

(*a*) Draw the whole block, very lightly.

(*b*) Draw lightly the bases of the prism, upon the proper faces of the block.

(*c*) Connect the **visible** corresponding points of both bases, (1 to 1; 2 to 2; 3 to 3, etc.) Line in.

Apply the same directions to the Desk-shaped Prism.

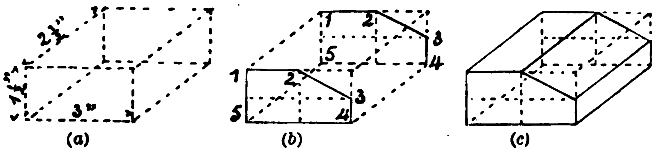


Fig. 56.

GENERAL RULES FOR DRAWING PRISMS.

1. Place the prism in the position desired.
2. Move the block to the proper station.
3. Name the faces you see.
4. Tell where the **bases** are (front and rear, up and down, etc.).
5. To sketch your model, use one of the methods described in this section or in the next.
6. **Line in only** the edges (lines) that are seen.
7. You **always see** the **front** of your model, but unless the block is transparent, you **never see** more than a few of the lines of the **rear.**
8. Do not make the farther base larger than the nearer.
9. The lines of the **front** should be drawn **heavier** than the lines of the **rear,** which must be **light.**
10. The unseen lines of the solid should be **very faint,** or **dotted.**

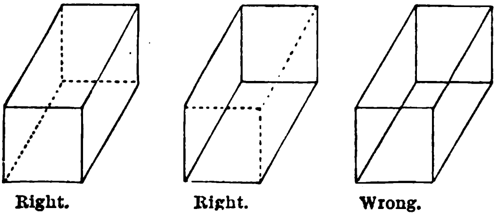


Fig. 57.

The Two Steps at stations 9, 6, and 8, are drawn in the same manner.

In the Book: Free hand, or with instruments, draw four views of the Desk-shaped Prism at stations 6, 7, 8, and 9.

SECTION 11.

REVIEW OF OBLIQUE PROJECTION. SHORTER METHODS.

Models: Use the cardboard and twine models of the Two Steps and the Desk-shaped Prism.

SECOND METHOD. To simplify method one:—

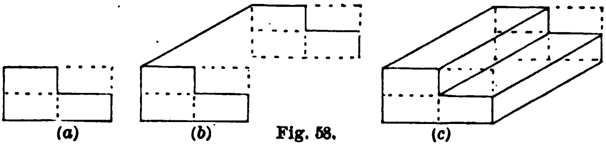


Fig. 58.

(*a*) **Draw the base you see.**

At the proper angle, draw a line (oblique in this case, vertical or horizontal in others) showing the direction of the second base, and its distance from the front base.

(*b*) Draw the second base very lightly, and exactly like the first base.

(*c*) Connect the **visible** corresponding points of both bases. Line in.

THIRD METHOD. Shorter still, but not so easily understood by beginners as the first method. **Draw only the lines actually seen.**

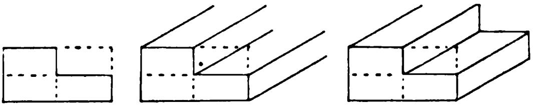


Fig. 59.

(*a*) **Sketch the bases you see.**

(*b*) Draw the visible oblique parallel lines connecting the two bases. Make them **all of the same length.**

(*c*) Draw the visible lines of the second base, parallel to the similar ones in the first base.

This method is used when the oblique lines are short, or to do away with the construction lines.

EXERCISES.

Draw very rapidly:—

1. By second method: Steps at station 9.
2. By third method: Steps at stations 6 and 8.

In the Book: With free hand, or instruments, draw views of the Desk-shaped Prism at stations 6 and 7, by the second method; and at stations 8 and 9, by the third method.

—— SECTION 12. ——

DECORATION.

GENERAL DIRECTIONS. SMALL BORDERS.

General Directions.

Each pupil should:

1. Take from the school collection of patterns, or bring to school, pieces of carpet, cloth, wall-paper, etc., containing the units used in each lesson.
2. Make or procure the units needed for each lesson; as, splints, colored papers cut to the proper shape, natural leaves, etc.
3. Arrange these units in different ways upon the desk or the slate, making patterns as directed.
4. Sketch the best designs, on paper, in the blank drawing-book, or upon the blackboard.
5. Read "*Harmony of Colors*" in Calkin's "*Manual of Object Teaching;*" or in other books on colors found in school or public libraries.

Different patterns are made with the same units, by varying:
1. Their **positions.** 2. Their **sizes.** 3. Their **angles.** 4. Their **distances.** 5. Their **lines** (changing **straight lines** into **curves,** or **curves** into **straight lines**). 6. By **adding** new lines. 7. By **subtracting** lines partially or entirely.

Units. Make 8 or 10 units of **each** of the following shapes:

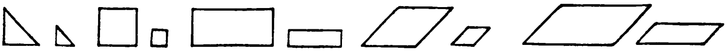


Fig. 60.

NOTE.—A square, cut on its two diagonals, will make four triangles. Work according to "**General Directions.**"

Read "**Notice**" before figure 42.

Unit: The triangle.

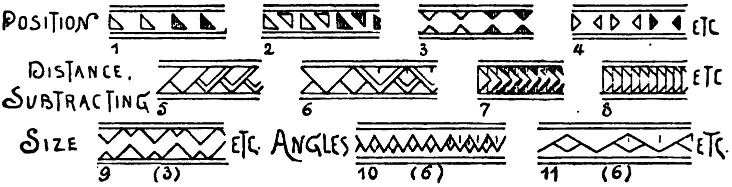


Fig. 61.

Unit: The square.

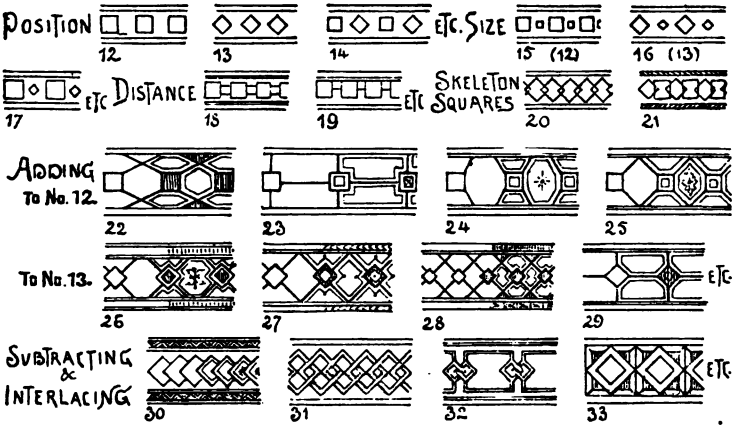


Fig. 62.

Unit: The oblong.

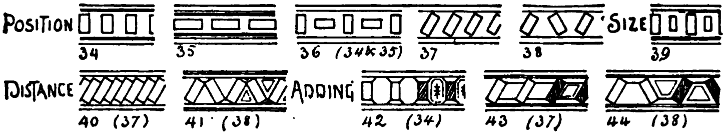


Fig. 63.

Units: The rhombs.

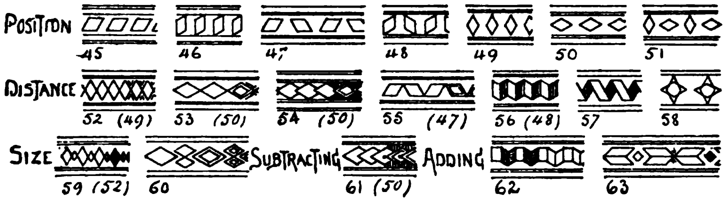


Fig. 64.

In the Book: Draw one or two borders composed of the foregoing units. Color them, or, if you have not the colors desired, draw in black, giving different shades to the units and to the background, according to the intensity of the coloring needed in the pattern; or, paste paper units upon paper of another shade or color.

CHAPTER II.

SECTION 13.

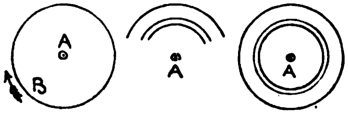
USE OF COMPASSES. DIVIDING CIRCLES INTO SIXTHS.

Read "**General Directions,**" Section 1.

Compasses are used to describe circles and arcs. The head or joint should be held between the thumb and the first two fingers of the right hand.

The steel and the pencil **points should be of the same length.** Do not use both hands to open and close the compasses. **Do not press hard** on either point of the compasses. The pencil point of the compasses should be wedge-shaped.

Problem 13. To describe a circle, with a given radius. One inch, for instance:



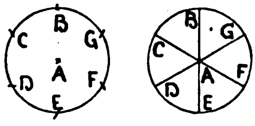
(a) (b)
Fig. 65.

(a) Draw center A. **Take off** (i. e. measure off or put between the points of the compasses) a radius one inch long. Placing the steel point of the compasses upon A, and beginning at point B, roll the head or joint of the compasses between your fingers, describing a complete circle.

Practice this exercise until it is well mastered.

(b) In the same manner, describe parallel arcs and concentric circles.

Problem 14. To divide a circle into sixths.



(a) Fig. 66. (b)

(a) Describe a circle, any radius.

(b) Set off this same radius six times upon the circumference of the circle. Try until you have six **equal** parts.

(c) Draw diameters connecting opposite points B E, C F, D G.

APPLICATIONS.

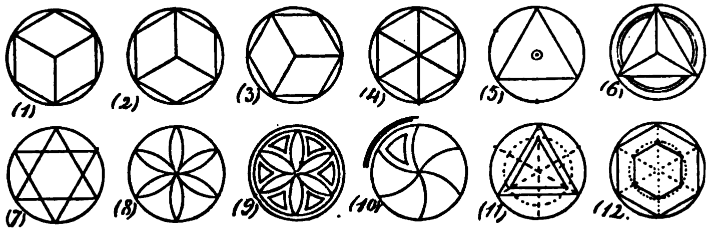


Fig. 67.

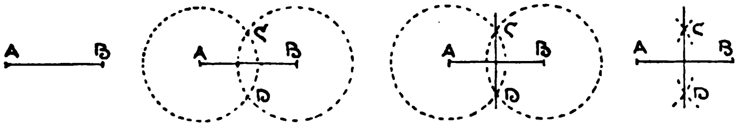
Parallel lines and arcs may be added to any of these figures.

In the Book: Draw several applications similar to those in figure 67.

—— SECTION 14. ——

COMPASSES. BISECTING. DIVIDING CIRCLES INTO EIGHTHS.

Problem 15. To bisect a given line, A B.



(a) (b) Fig. 68. (c) (d)

(*a*) Draw line A B, with cross lines to mark its extremities.

(*b*) With A and B as centers, and a radius large enough, describe equal **secant** cutting **circles.**

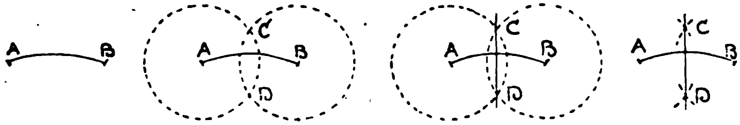
(*c*) Draw line C D.

(*d*) Describing whole circles is unnecessary; arcs intersecting in C and D are sufficient.

Draw the same problem in different positions. **Do not guess** at the operations.

Problem 16. To bisect an arc of a circle.

Work exactly as in problem 15.



(a) (b) Fig. 69. (c) (d)

In different positions:

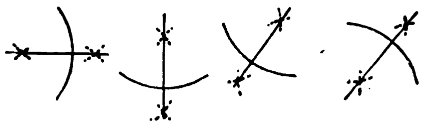


Fig. 70.

APPLICATIONS.

To divide a circle into 4, 8, 16, etc., equal parts.

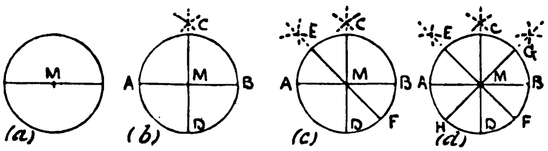


Fig. 71.

(*a*) Describe a circle, and draw its diameter M.

(*b*) Bisect diameter A M B. (Quadrants).

(*c*) Bisect arc A C. Produce the line to F. *The line bisecting an arc* **always** *passes through the center of the circle to which that arc belongs.*

(*d*) Bisect C B. Produce the line to H.

Fig. 72.

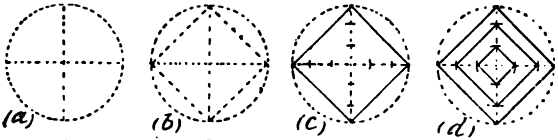


Fig. 73.

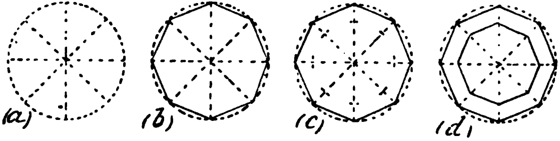
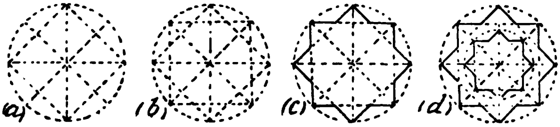


Fig. 74.

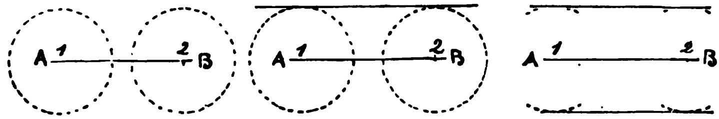


In the Book: Draw four of the foregoing problems, or their applications.

SECTION 15.

COMPASSES. TANGENT CIRCLES.

Problem 17. To draw a line parallel to a given line, A B, at a given distance from it. Distance ¾".



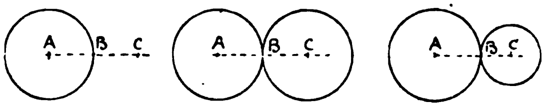
(a) (b) (c)
Fig. 75.

(a) Draw line A B. With a ¾" radius, describe circles having their centers, 1 and 2, anywhere in line A B.

(b) Draw the line **tangent** to the circumferences of the circles.

(c) The same, with *two* tangent lines. It is not necessary to describe whole circles; arcs are sufficient.

Problem 18. To describe circles tangent **externally.**



(a) (b) (c)
Fig. 76.

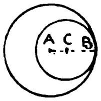


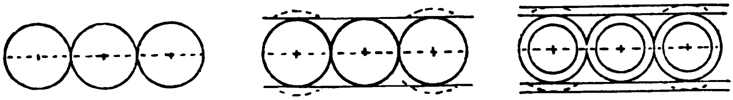
Fig. 77.

(a) Rule line A. From center A, any radius, describe a circle. From B, set off the radius of the second circle in C.

(b) From center C, radius C B, describe tangent circle.

(c) Same problem, with circles of different radii.

Fig. 77. Same problem; circles tangent **internally.**
Work similarly.



(a) (b) (c)
Fig. 78.

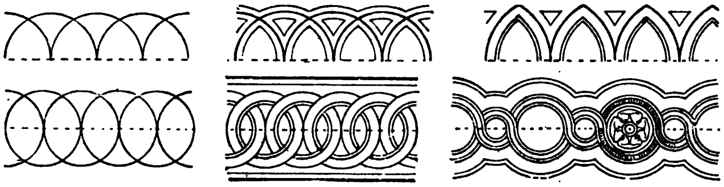


Fig. 79.

In the Book: With instruments, draw several of the foregoing, or similar figures.

—— SECTION 16. ——

USE OF DIVIDERS.

Compasses with steel points are called **dividers**. They are used for dividing, or transferring lengths and distances.

Read about compasses, Section 13.

Problem 19. With dividers, to bisect a given line by trial. Line 2 ⅝″ long.

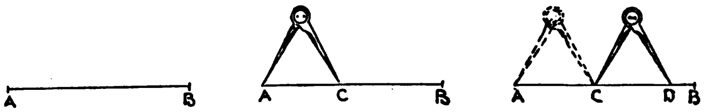


Fig. 80.

(*a*) Draw line A B, with cross lines at its ends.

(*b*) Placing one of the points of the dividers upon A, move the other point until it appears to be upon the middle of the line A B.

(*c*) Revolve the dividers upon the steel point (on C,) making another span equal to A C.

If, as in this figure, the dividers fail to reach B exactly, (without moving the steel point from C) increase the second span by ½ the difference between B and D; then, beginning again at A, try anew until you succeed.

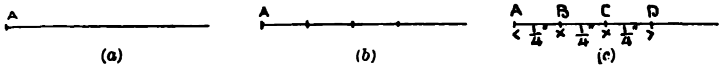
Should the first span be too great, reduce it by one-half the excess.

Problem 20. With dividers, to divide by trial a given line into 3ds, 5ths, etc.

Proceed as in the last example. If there is a difference, the span should be reduced, or increased, by one-third, or one-fifth, etc. of that difference.

If you do not succeed at first, try, try, try again.

Problem 21. With dividers, to set off equal lengths along a line. Given lengths $\frac{1}{4}''$.



(a) (b) (c)

Fig. 81.

(*a*) Draw an indefinite line, A.

(*b*) Measure off $\frac{1}{4}''$ with the dividers, and, beginning at point A, prick the paper, along the line, as many times as needed.

(*c*) Draw cross lines, letters, etc.

EXERCISES.

1. Draw similar exercises, taking other dimensions and using vertical and oblique lines.

2. By trial, divide a number of circles and arcs into several equal parts.

In the Book: With dividers, by trial, divide a circle into 5ths., 9ths., 10ths., etc., and make a design.

SECTION 17.

DECORATION.

BORDERS. CIRCLES AND DOUBLE SEGMENTS.

Models.—Colored paper circles of two or three dimensions; double segments of different sizes, fig. 83.

Work according to "**General Directions,**" Section 12.

In making a pattern with circles, you may change:—

1. Their size. 2. Their shape (ellipse, oval). 3. The distances from centers to centers. 4. You may use parts of circles (sectors, segments). 5. Add or subtract.

Samples. Free hand, or with instruments:

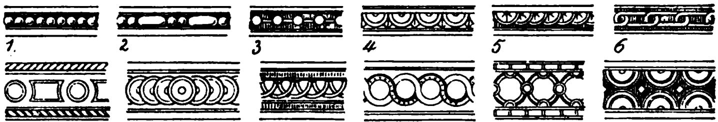


Fig. 82.

DOUBLE SEGMENTS.

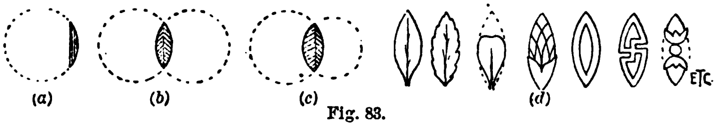


Fig. 83.

(a) Segment. (b) and (c) Double segments. (d) Modifications.

A few combinations:

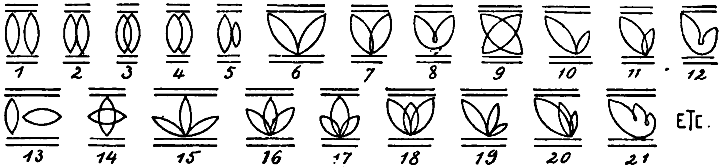


Fig. 84.

APPLICATIONS.

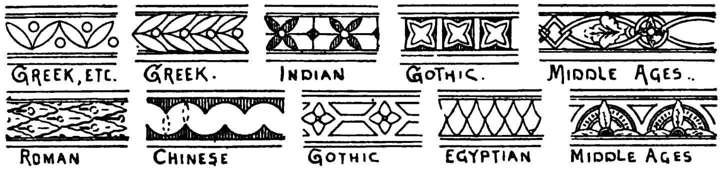


Fig. 85.

In the Book: Draw a few of the foregoing, or similar borders.

SECTION 18.

OBLIQUE PROJECTION. BASES OF PRISMS FACING UP AND DOWN, RIGHT AND LEFT.

Models:—The Two Steps, the Desk-shaped Prism, etc.

In an oblique projection, you will notice that although **all** the faces of a cube are **squares,** its upper, lower, left, and right faces **are drawn as rhombuses** (fig. 86).

For the same reason, oblongs are represented by rhomboids, (fig. 87).

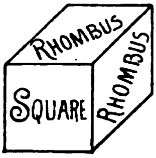


Fig. 86.

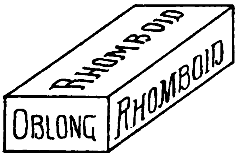
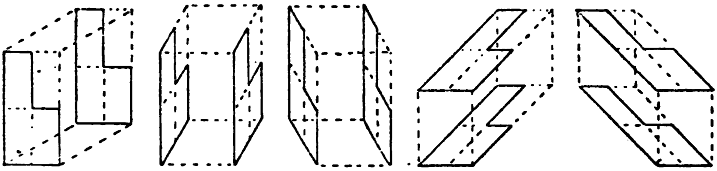


Fig. 87.

All the divisions and figures drawn upon the oblique faces of these solids are changed in the same way, i. e., a square division becomes a rhombus; an oblong division, a rhomboid; etc.



(a) (b) Fig. 88. (c)

This enables us to draw the bases of any prism, facing not only front and rear (*a*), but also left and right (*b*), up and down (*c*).

In the same manner, any of the following front and rear bases may be turned up and down, left and right: Stations 7 and 9, or 6 and 8.

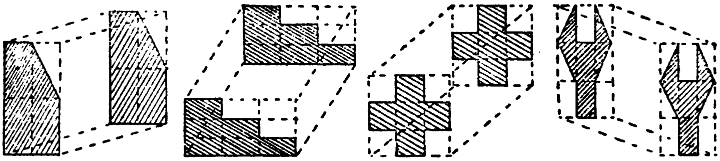
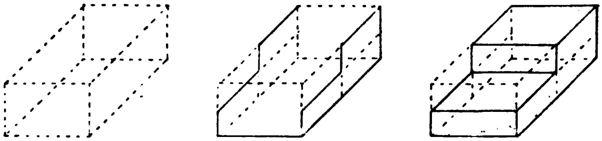


Fig. 89.

Now, move the model to station 7, in the position shown in (*c*) fig. 90.

NOTE. The following methods have already been explained in Sections 10 and 11. The only change consists in drawing the bases up and down, left and right, instead of front and rear.

First Method.



(a) (b) (c)

Fig. 90.

Second Method.

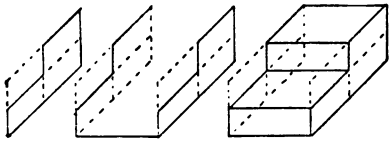


Fig. 91.

Third Method.

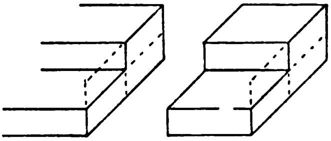


Fig. 92.

Caution. Do not draw an oblong for a rhomboid; ex:—

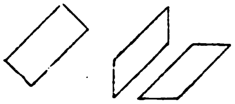


Fig. 93.

By one of these methods, **draw rapidly**, free hand, the Desk-shaped Prism. Bases up and down. Station 7. Turn your sketch about in front of your eye, to have other views of it.

Move the models to the stations, and turn them in the different positions required to have the following views of them.

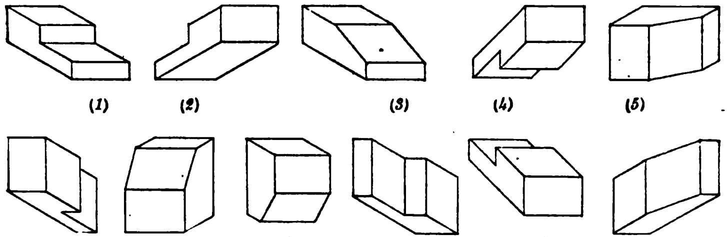


Fig. 94.

In the Book: Draw, either free hand or with instruments, several sketches of the Steps, and of the Desk-shaped Prism.

SECTION 19.

FREE HAND DIVISION OF LINES INTO FIFTHS.

1—(*a*) Free hand, shoulder movement, draw a horizontal line, any length. (*b*) By guess, divide the line into fifths. (*c*) With a piece of paper, measure off $\frac{1}{5}$, and find out if all the other divisions are alike.

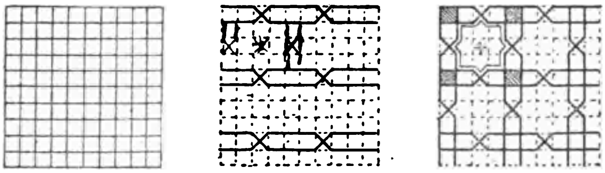
Caution. **Do not correct** your work; simply find out your mistakes.

Putting the measure aside, try again with lines of different lengths and in different positions. Examine your work at arm's length.

After a few times, **do not measure any more; trust your eye entirely.**

2. In the same manner, and without measuring, divide a four or a six inch square into twenty-five equal squares—into 100 equal squares.

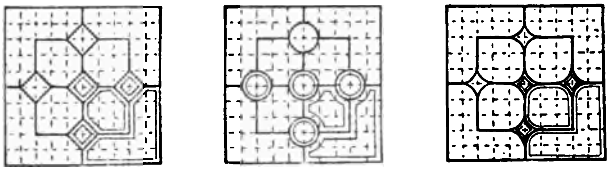
APPLICATIONS.



(a) (b) (c)

Fig. 95.

You may change some of the straight lines into curves, add double lines, etc. Examples:—



(1) (2) (3)

Fig. 96.

In the Book: Make an original design on the 100 square pattern, or copy one of the foregoing figures.

—— SECTION 20. ——

MAKING PRISMS WITH TRIANGULAR AND HEXAGONAL BASES.

Problem 22. With instruments, to construct an equilateral triangle upon a given base. Base 2″ long.

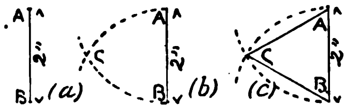


Fig. 97.

(a) Draw line A B, 2″ long.

(b) With A and B as centers, and a radius equal to the length of the base, describe arcs intersecting in C.

(*c*) Connect A C and B C.

Problem 23. To construct a regular hexagon upon a given base. Base 1″ long.

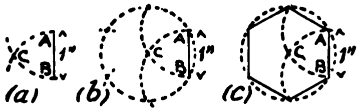


Fig. 98.

(*a*) Draw vertical line A B, 1″ long. Find point C by last problem.

(*b*) With C as a center, radius A B, describe a circle; divide its circumference into sixths.

(*c*) Connect the points of division.

Follow carefully **"Directions for making paper Prisms,"** Section 6.

In the same manner, make one or both of the following prisms:

EQUILATERAL TRIANGULAR PRISM.

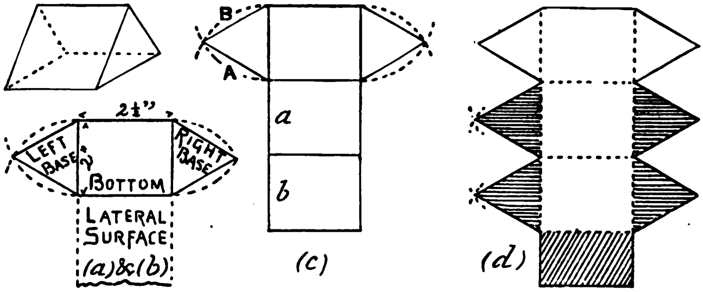


Fig. 99.

REGULAR HEXAGONAL PRISM.

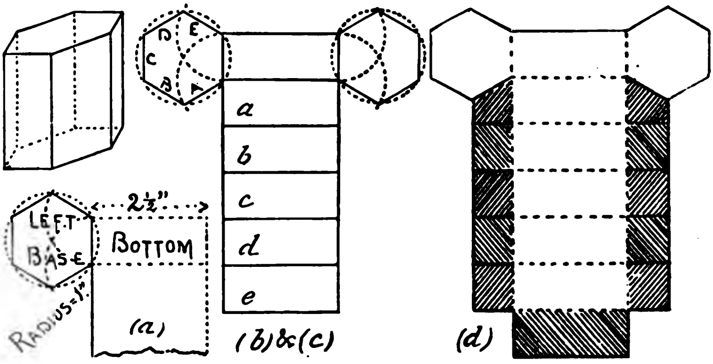


Fig. 100.

SKELETON MODELS.

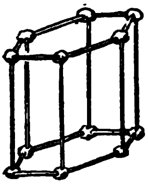


Fig. 101.

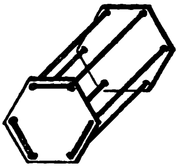


Fig. 102.

In the Book: (Optional). Work out these models as the Two Steps in Section 6.

—— SECTION 21. ——

OBLIQUE PROJECTION.
TRIANGULAR AND HEXAGONAL PRISMS.

With instruments, draw rapidly the bases of a Triangular Prism in different positions. Example :—

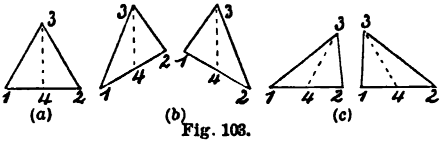


Fig. 103.

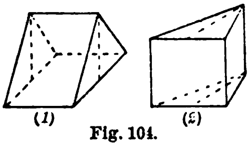


Fig. 104.

(*a*) Bases front and rear. (*b*) Bases right and left. (*c*) Upper and lower bases.

In these examples, base lines 1–2 are all the same length, and altitude lines 3–4 are all the same length.

Use one of the methods in Sections 10, 11 or 18, to draw this solid in different positions and at different stations.

The Hexagonal Prism is worked in the same manner.

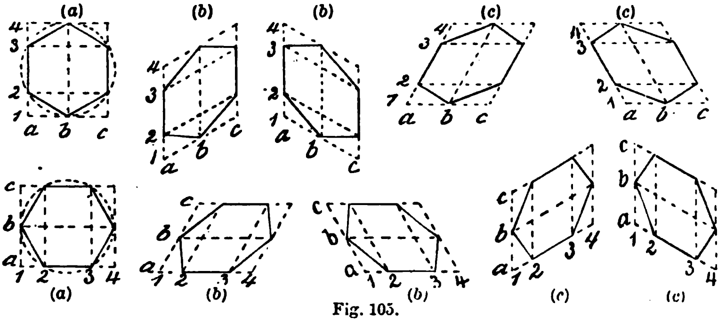
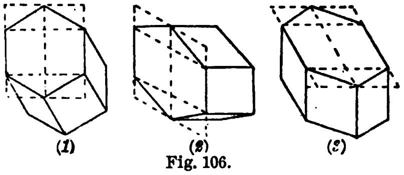


Fig. 105.

Note. The dimensions of the rhombs and their divisions in (*b*) and (*c*) are exactly those of the oblongs in (*a*).

Draw this solid in different positions, and at different stations. Samples:—



(1) (2) (3)

Fig. 106.

In the Book: Sketch four different views of these solids. Free hand, or with instruments.

—— SECTION 22. ——

OBLIQUE PROJECTION.

BLOCK LETTERS. BASES FRONT AND REAR.

Instead of the inch, **any length** may be used as a unit of measurement.

Make an oblong 5 *lengths* high by 3 *lengths* wide. Divide by *lengths* as in first oblong, fig. 107.

All letters of the alphabet may be made upon this frame, except I which is 1 length wide, J 2½, M 4 or 4½, and W five lengths.

However, in the following alphabet an additional ½ length has been given to the width of letters A, K, V, X, and Z.

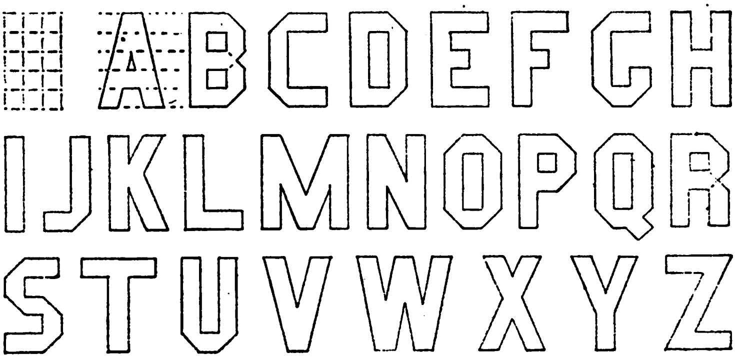


Fig. 107.

Draw six long horizontal lines, and vertical lines making squares with the others. Sketch rapidly the initials of your names.

When these letters are cut from metal, wood, or stone, they are real prisms whose ends or **bases** are the faces of the letters. Draw them as you did the other prisms.

Draw block letters 5 lengths high, 3 lengths wide, and ½ length thick. Faces front and rear. Imagine these letters to be at one of the four stations, 6, 7, 8, or 9, on the imaginary board. Section 10, fig. 52. Example:

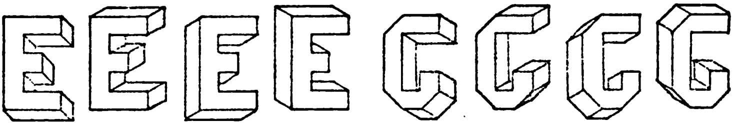


Fig. 108.

In the Book: Print your name, or that of the school; — a short motto; — a title, etc.

—— SECTION 23. ——

BLOCK LETTERS IN DIFFERENT POSITIONS.

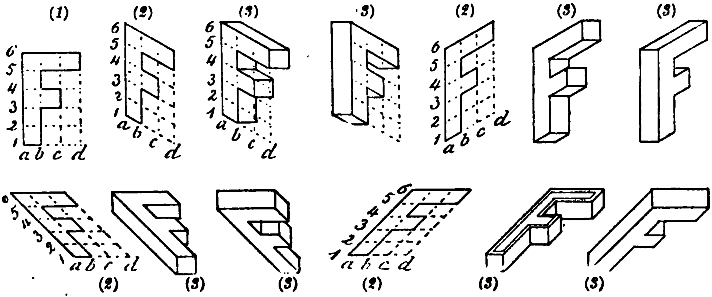


Fig. 109.

Faces of letters in different positions.

(1) Front face of the block letter. To distinguish the horizontal from the vertical lines, **number** one set and **letter** the other.

(2) (2) (2) (2) Faces fronting left and right, up and down.

(3) (3) (3).... The same with the thickness.

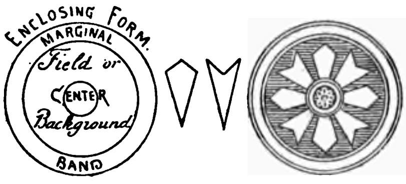
In the Book: As in last section, print names, mottoes, etc.

SECTION 24.

DECORATION.

PARTS OF A DESIGN. SYMMETRICAL TRAPEZIUMS.

The parts of a design are generally:—



(a) (b) (c)

Fig. 110.

1. The **enclosing form,** (*a*).

2. The **divisions of the enclosing form:**—The marginal band (*a*); the center (*a*); the **main and construction lines.**

3. The **unit** or **units** (*b*), which should cover about two-thirds of the space within the enclosing form. This space is called:

4. The **field or background** (*a*). The part of it not covered by the units is shaded in (*c*).

Models: Colored paper units, as in (*b*), fig. 110.

Work according to "General Directions," Section 12.

Read "**Note**" before fig. 42, Section 7.

Samples:

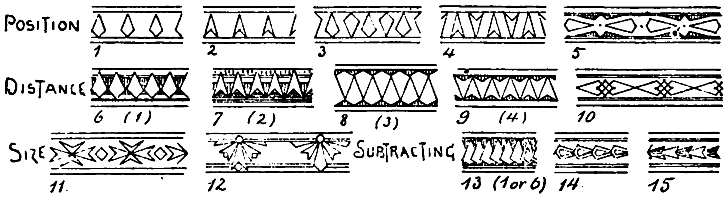


Fig. 111.

Samples of Rosettes:

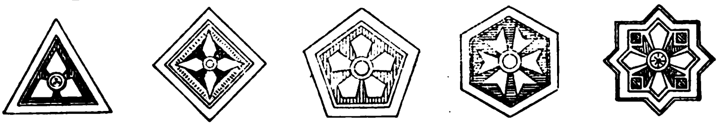


Fig. 112.

In the Book: Draw a few of the foregoing, or similar patterns. Finish them as in fig. 44, Section 7.

Some of the lines may also be changed into curves.

CHAPTER III.

SECTION 25.

DRAUGHTSMAN'S SCALE.

A **point** has position, not dimension. As points cannot be seen, small dots are used.

Caution. Make your points (dots) dark but very small.

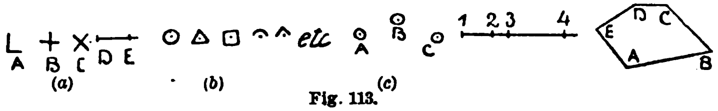


Fig. 113.

(*a*) The place where the two lines meet or cross each other is called a point. A, B, C, D, E, are points.

(*b*) In order to be more easily found, points are sometimes surrounded by squares, triangles, etc.

(*c*) **Letters** (A, B, C, etc.), or figures (1, 2, 3, etc.), are used for the names of points.

DRAUGHTSMAN'S SCALE.

A **scale** is a contrivance by which any small distance, as an inch, for instance, is taken to represent a foot or any other measure of length.

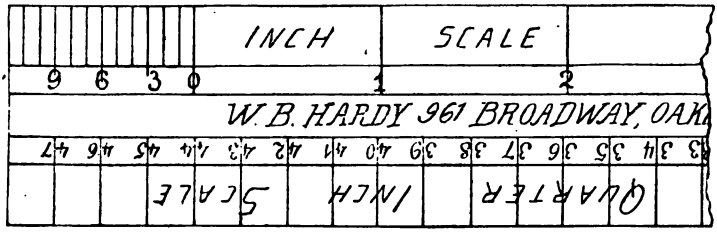


Fig. 114.

Place the scale in front of you, so that the **inch scale** shall be on the upper edge, fig. 114.

REMEMBER:—

1. That **each** of these **inch spaces** on the scale, represents **one foot.**

2. That **each** $\frac{1}{12}$ of an **inch space** on the scale, represents **one inch.**

3. That spaces representing **feet** are on the **right,** and that spaces representing **inches** are on the **left** of the **zero-line.**

Therefore, begin to count the **feet from the zero-line to the right,** and the **inches from the zero-line to the left.** (Fig. 115.)

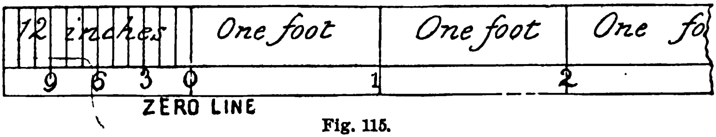


Fig. 115.

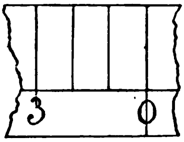


Fig. 116.

Caution. Do not mistake **lines for spaces;** for instance, do not call the three spaces in fig. 116, four inches because you see **four** vertical lines. You have but **three spaces** or **three inches.**

Problem 24. To set off distances with the scale.

NOTE. To *set off* or *lay off* a length is to *mark off* the *extreme points* of a given length.

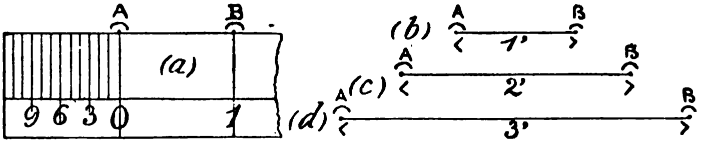


Fig. 117.

1. Using the **inch-scale,** draw lines representing 1′, 2′, 3′.

(*a*) Place the inch-scale as directed above. Draw dot A opposite the **zero-line,** and dot B opposite the **foot-line 1** on the right.

(*b*) Connect A B; write conventional signs and the length.

(*c*) and (*d*) Proceed in the same manner for the 2′ and the 3′ lines.

Repeat the same exercise with vertical and oblique lines.

2. To set off 1′ + 2′ along a line.

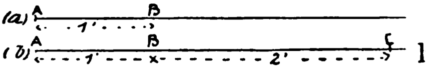


Fig. 118.

(a) Draw an indefinite line, A.

Place **zero-line** of the scale close to point A; draw point B opposite line 1 on the right of **zero-line.**

(b) Move **zero-line** opposite B; draw C opposite 2 on the right.

Another way is to draw B one foot from A, and then C opposite line 3, without moving the scale.

Do not forget to write dimensions, conventional signs, etc.

Repeat the same exercise with vertical and oblique lines.

—— SECTION 26. ——

DRAUGHTMAN'S SCALE. (Continued.)

3. To draw 3″, 6″, and 9″, respectively, with the scale.

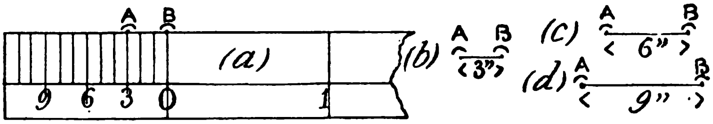


Fig. 119.

(a) Draw point A opposite the 3″ line, and B opposite the zero-line.

(b) Remove the scale, and connect A B. Write lengths, etc.

(c) and (d) Draw 6″ and 9″ lines in the same manner.

Repeat the same exercise with vertical and oblique lines.

4. To set off 3″, 6″, 9″ along a line.

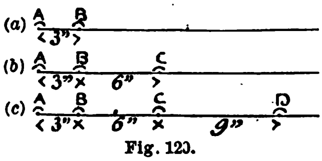


Fig. 120.

(a) Draw line A, any length. Place the 3″ line upon A. Draw B opposite the zero-line.

(b) Move the scale until the 6″ line is opposite B. Draw C opposite the zero-line.

(c) Move the scale again, placing the 9″ line upon C. Draw B opposite the zero-line.

Draw similar exercises with vertical and oblique lines.

5. To set off along a line 4″ + 5″ + 7″ + 2″ + 8″ + 10″. Proceed as in last exercise.

Draw similar exercises with vertical and oblique lines.

6. To set off along a line 1′ 3″ + 1′ 6″ + 1′ 9″.

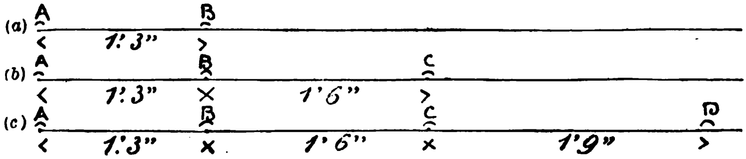


Fig. 121.

(*a*) Draw an indefinite line, A. Place inch line 3 upon A. Draw B opposite foot line 1.

Caution. Do not draw any mark opposite zero-line.

(*b*) Move the scale until the 6″ line is opposite B. Draw C opposite foot line 1.

(*c*) Place 9″ line upon C. Draw D opposite foot line 1. Write dimensions, signs, etc.

Draw similar examples with vertical and oblique lines.

Measure objects—desks, charts, boxes, teacher's table, panels, width of doors, windows, benches, height of blackboard, pupil's desks, chairs, etc. Draw the same according to the inch-scale.

7. To draw an indefinite line, and to find the length it represents, according to the inch-scale.

Draw a line with cross lines at its ends, measure with the scale, write conventional signs, number of feet and inches, etc.

Draw other exercises of the same kind with vertical and oblique lines

In the Book: Draw samples of the foregoing work. Be **very accurate.** Have pencils with sharp points.

—— SECTION 27. ——

COMPASSES. PERPENDICULAR LINES.

Problem 25. To erect a perpendicular line through the middle of a given line.

Work this problem exactly as Problem 15, Section 14, "To bisect a given line."

Problem 26. To erect a perpendicular line at the extremity, B, of a given line, A B.

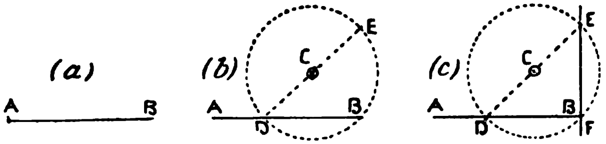


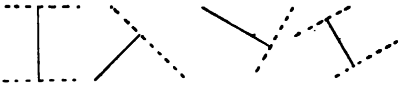
Fig. 122.

(*a*) Draw A B.

(*b*) Describe circle B D, taking as its center any point, C, anywhere outside and opposite A B.

(*c*) Draw diameter D C E, and perpendicular line E B F.

Erect lines perpendicular to the following given lines:

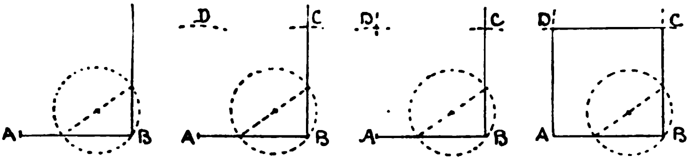


The dotted lines show where the perpendicular lines are desired.

Fig. 123.

Problem 27. Construct a square upon a given base. (No triangle used; no guess work.)

Base 2″ long.



(*a*) (*b*) Fig. 124. (*c*) (*d*)

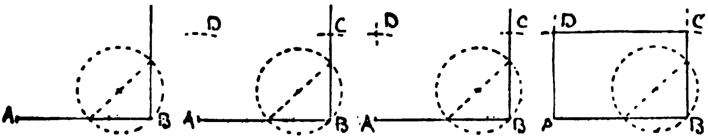
(*a*) Draw base A B, 2″ long. Erect perpendicular line at B.

(*b*) Take off A B and set it off in A D and in B C.

(*c*) With the same radius, and C as a center, describe another arc in D.

(*d*) Connect D A, and D C.

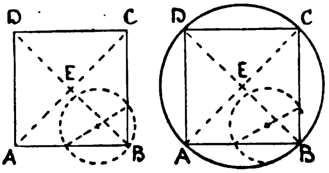
Problem 28. To construct an oblong of given dimensions. Oblong 2″ by 3″.



(*a*) (*b*) Fig. 125. (*c*) (*d*)

Read Problem 27. Change only the dimensions.

Problem 29. To circumscribe a circle about a given square.

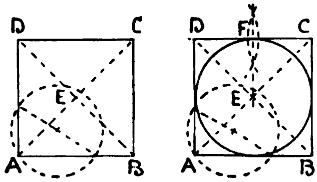


(a) Fig. 126. (b)

(*a*) Construct the square draw its diagonals to find its center.

(*b*) From its center E, radius A E, describe circle A B C D.

Problem 30. To inscribe a circle within a given square.



(a) Fig. 127. (b)

(*a*) Construct the square, and draw its diagonals. To find the length of the radius of the inscribed circle, bisect D C, in F E.

(*c*) With center E, radius E F, describe the circle. It should be **tangent and not secant.**

In the Book: Draw any of the foregoing problems.

—— SECTION 28. ——

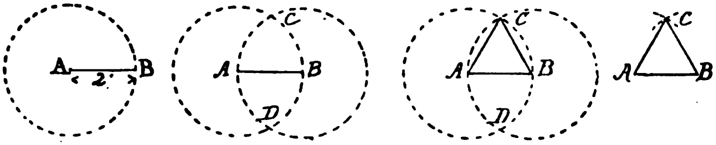
COMPASSES.

TRIANGLE CONSTRUCTION. PERPENDICULAR LINES.

An equilateral triangle has *three equal* sides.
An isosceles triangle has *two equal* sides.
A scalene triangle has *no equal* sides.

Problem 31. To construct triangles, the three sides of each being given.

1. An equilateral triangle: base 2′.



(a) (b) Fig. 128. (c) (d)

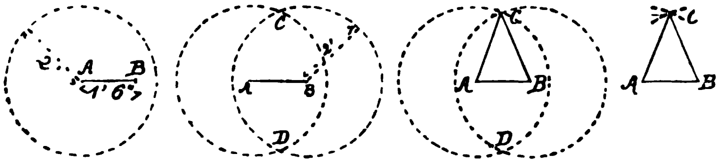
(*a*) 2′ base. Radius A B, center A, describe a circle.

(*b*) Same radius, center B, describe another circle.

(*c*) Connect C A, C B.

(*d*) The same, simplified.

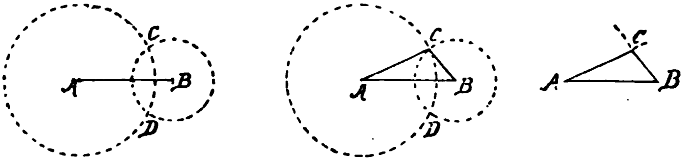
2. An isosceles triangle: base 1′ 6″; sides 2′ each.



(*a*) (*b*) Fig. 129. (*c*) (*d*)

This is the same problem as the last. The only difference is in the length of the radius for the sides.

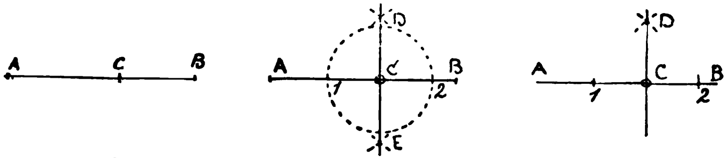
3. A scalene triangle: sides 1′, 1′ 6″, and 2′.



(*a*) (*b*) (*c*)
Fig. 130.

This is again the same problem, except in the length of the radii.

Problem 32. At any point in a given line, to erect a perpendicular to that line.



(*a*) (*b*) (*c*)
Fig. 131.

(*a*) Draw line A B and given point C.

(*b*) With C as a center, any radius, describe a circle. Bisect 1–2 upon line A B.

(*c*) The same simplified.

Draw similar problems with vertical and oblique lines.

Problem 33. From a given point outside of, and opposite a given line, to erect a perpendicular to that line.

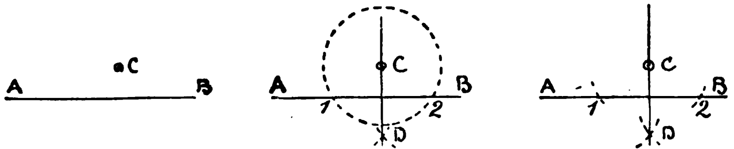


Fig. 132.

Same directions as in last problem.

Application. To find the altitude of any triangle.

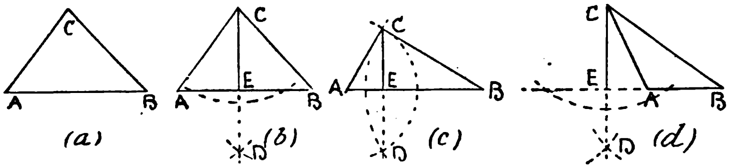


Fig. 133.

(*a*) Construct a triangle.

(*b*) From C, erect a perpendicular to A B, as in Problem 33. C E is the altitude wanted.

(*c*). Another method. From center A, radius A C, describe arc C D. From center B, radius B C, describe arc C D. Connect C D. The altitude is C E.

(*d*) When the vertical angle C, is not opposite the base A B, extend A B.

In the Book: Draw examples of each of the foregoing problems.

—— SECTION 29. ——

ENCLOSING FORMS FOR ROSETTES.

MARGINAL BANDS.

Marginal bands should be neither too broad nor too narrow. They should not attract more attention than the center of the design.

Enclosing forms:—

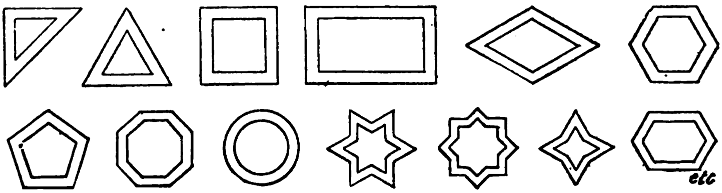


Fig. 134.

New enclosing forms are made:—

(*a*) By changing the corners of polygons. An oblong, for instance:

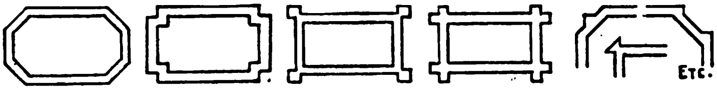


Fig. 135.

(*b*) By changing the middle of the sides:

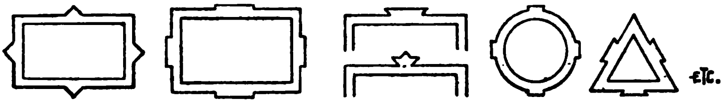


Fig. 136.

(*c*) By changing straight lines into curves:

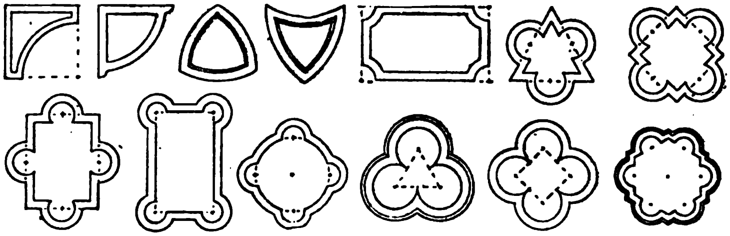


Fig. 137.

In the Book: With instruments, draw several of the above or similar enclosing forms with their marginal bands.

SECTION 30.

PAPER MODELS OF PRISMS HAVING IRREGULAR BASES.

Review Section 6.

Dividing the bases into unequal parts:

Modifications of the Two Steps.

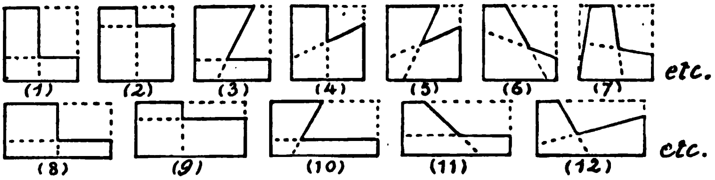


Fig. 138.

Modifications of the Greek Cross.

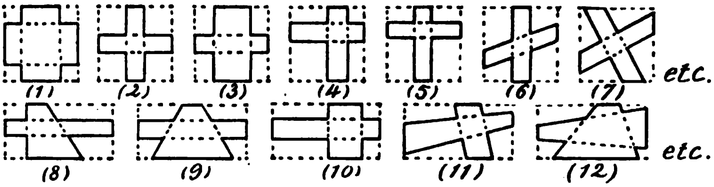


Fig. 139.

All prisms should be made according to "**General Method for making paper prism,**" **Section 6.**

Sample of a paper prism having irregular bases:—

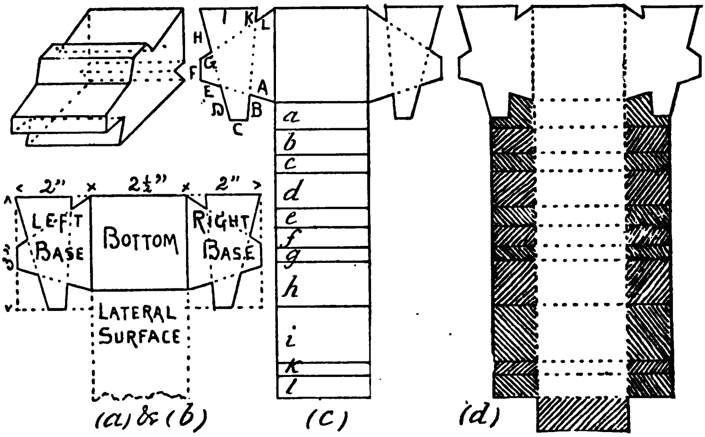


Fig. 140.

Make a paper prism with bases different from those used by anyone else in your class.

In the Book: (Optional).

See "In the Book," Section 6.

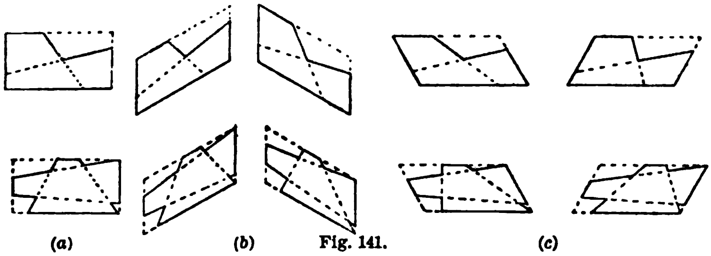
—— SECTION 31. ——

OBLIQUE PROJECTION.

PRISMS HAVING IRREGULAR BASES.

With the construction lines left upon the bases of your model, you will readily find the original shape and divisions of these bases. Reproduce the same with their real dimensions.

Examples of bases in different positions:



(a) (b) Fig. 141. (c)

(*a*) Bases facing front and rear.
(*b*) Bases facing right and left.
(*c*) Bases facing up and down.

In the same manner draw the visible base of the prism you have made; then draw the thickness of the solid.

Do not draw the following examples:

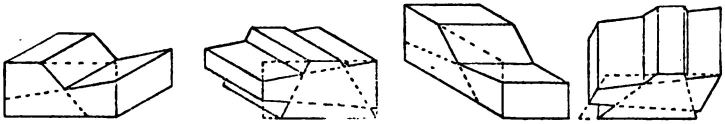
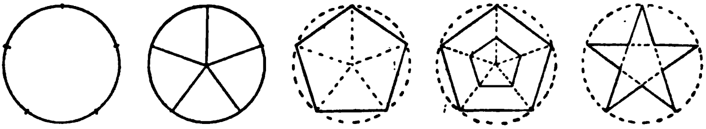


Fig. 142.

In the Book: Free hand or with instruments, draw four different views of prisms having irregular bases.

—— SECTION 32. ——

FREE HAND, DIVIDING CIRCLES INTO FIFTHS.



(a) (b) (c) (d) (e)
Fig. 143.

(*a*) Describe a free hand circle.
(*b*) Upon its circumference, by guess, space five dots equally.

Do not measure. Trust your eye.

For better examination, turn the work about, at arm's length, in front of your eye.

Applications: (*c*), (*d*), (*e*), fig. 143.

To divide a circle into 10ths, bisect each fifth by extending each radius until it becomes a diameter.

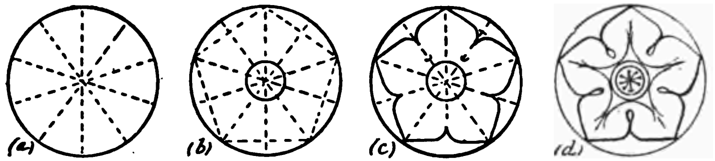


Fig. 144.

(*a*) Circle divided into tenths.

(*b*) Regular pentagon. Describe the inner circle with a radius equal to about ¼ the radius of the large circle.

(*c*) Add tangent curves on the middle of each side of the pentagon.

(*d*) Add details and a marginal band. The latter, however, is not shown in the figure.

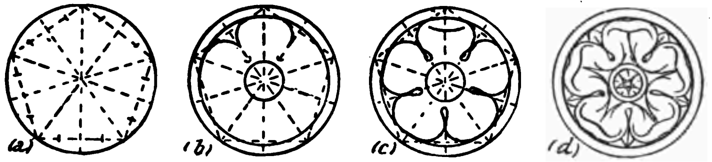


Fig. 145.

Rosette. (*a*) Regular pentagon. Divide its sides into fourths.

(*b*) Through last points of division, describe light tangent curves.

(*c*) Draw eyes and lines of curling petals.

(*d*) Finish petals by drawing reversed curves; draw center, etc. **Do not measure.** Examine the work at arm's length. Use shoulder movement. Work **rapidly** and **lightly.**

In the Book: Draw rapidly one of the foregoing figures, on as large a scale as possible; leave at least one inch margin.

SECTION 33.

ORTHOGRAPHIC PROJECTIONS.
WORKING DRAWINGS.

Models. An oblong prism, chalk boxes, and other similar objects.

Solids have three dimensions: height, width, and length.

In this book, by *height* is meant the distance from the lower to the upper side of a solid; by *width*, the distance from the right to the left side; by *length* or *thickness*, the distance from the front to the rear.

Place the model at station 1, in such a position as to see one of its faces only. Draw that face. You have drawn the **height** and the **width** of the model. This is called the **front view,** or **front elevation.** B in (*b*) fig. 146.

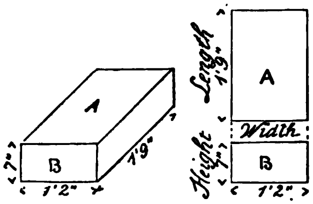
Now, place the same model on your lap; then, looking down, move your head over it until you see only the top of the solid. Draw that face above the elevation. You have drawn the **width** and the **length** of the solid. This is called the **top view,** or **plan.** A in (*b*) fig. 146.

In both cases, the model is supposed to be flattened against the wall, or against the floor, each line and point being **projected** perpendicularly to those surfaces.

Draw the plan **above** the elevation. Sometimes the plan is drawn below the elevation, or even on a separate piece of paper.

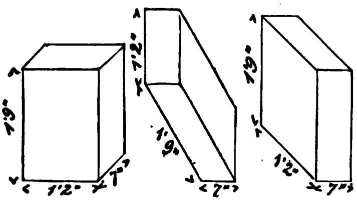
In (*b*), figure 146, the dotted lines show the connection between the plan and the elevation.

When the dimensions of the lines are given, these drawings are called **working drawings.**



(*a*) (*b*)

Fig. 146.



(*1*) (*2*) (*3*)

Fig. 147.

Draw the working drawings of the same oblong prism in the positions shown in fig. 147.

In the same manner, measure and draw the working drawings of a chalk box, or any other small cubical box.

On paper use your inch-scale, taking three inches of the scale for each real inch of the box.

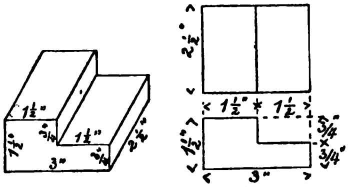
In the Book: Draw the working drawings of a box. Write its dimensions.

SECTION 34.

WORKING DRAWINGS. (Continued.)

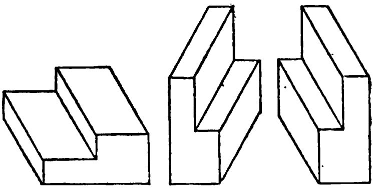
CAUTION. Do not work this section unless each pupil has the proper model (Two Steps) to work with.

1. To draw the working drawings of the Two Steps in the position shown in (*a*), fig. 148. Bases front and rear.



(*a*) (*b*)

Fig. 148.



(*1*) (*2*) (*3*)

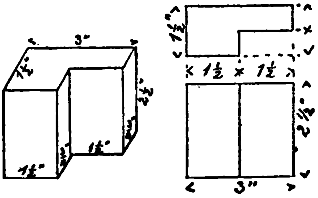
Fig. 149.

Begin with the elevation. To form a better idea of the plan, place the model on your lap; then, looking down, move your head over it, until you *see* its *horizontal faces only.*

RULE: Vertical surfaces are never drawn on a plan.

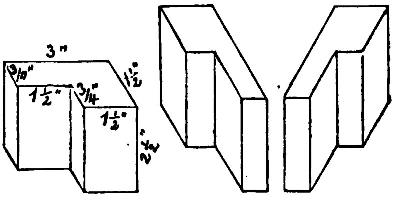
Freehand, draw rapidly the plan and elevation of (1), (2), (3), fig. 149.

2. To draw the working drawings of (*a*), fig. 150. Bases facing up and down.



(*a*) (*b*)

Fig. 150.



(*1*) (*2*) (*3*)

Fig. 151.

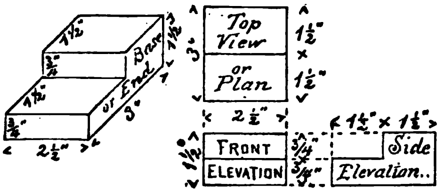
Draw the plan first, because it gives you one of the bases.

To have a correct view of the elevation, move the model, at arm's length, opposite your sight, until you *see* the *vertical faces only.* You must not see the right or the left, the upper or the lower faces.

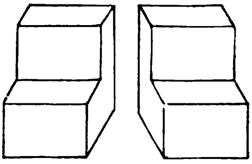
RULE: Horizontal surfaces are never drawn on an elevation.

Draw the working drawings of the Two Steps in the positions shown in (1), (2), (3), fig. 151.

3. To make the working drawings of (*a*), fig. 152. Bases right and left.



(*a*) (*b*) (*c*)
Fig. 152.



(1) (2)
Fig. 153.

In this case we need a **side elevation**, because the bases are neither in front nor on top, and we would not otherwise have a clear description of the Two Steps.

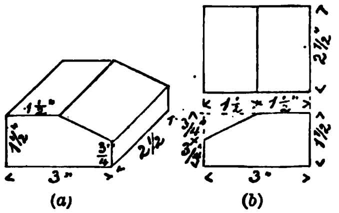
Draw the working drawings of (1) and (2), fig. 153.

In the Book: Draw two different views of the model (in oblique projection); then, under each sketch make the working drawings of the same according to its position. Use the model, divide the page into halves by a vertical line through its center. Write dimensions and the words, "Plan," "Elevation."

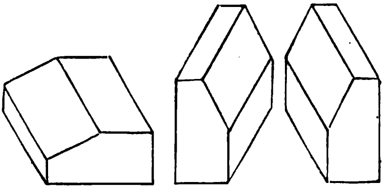
SECTION 35.

WORKING DRAWINGS. (Continued).

1. To draw plan and elevation of (*a*), fig. 154.



(*a*) (*b*)
Fig. 154.

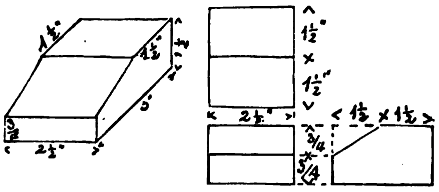


(1) (2) (3)
Fig. 155.

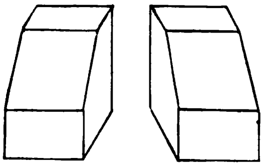
If you have any difficulty in finding the plan, move your model as you did for the Two Steps. Section 34, fig. 148.

Draw the working drawings of (1), (2), (3), fig. 155.

(2). To draw the working drawings of (*a*), fig. 156.



(*a*) (*b*) (*c*)
Fig. 156.

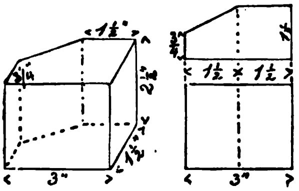


(1) (2)
Fig. 157.

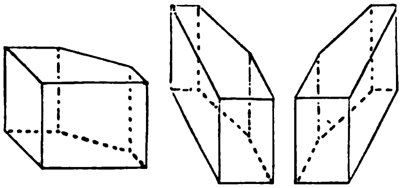
Here, as in figure 152, Section 34, we need a **side elevation;** otherwise these working drawings may be taken for those of the Two Steps, (*b*), fig. 152.

Draw the working drawings of (1) and (2), fig. 157.

3. To draw the plan and elevation of (*a*), fig. 158.



(*a*) (*b*)
Fig. 158.



(1) (2) (3)
Fig. 159.

In (*b*), dot-and-dash line represents an invisible line (edge) at the rear of the solid.

RULE. In Plans and Elevations, when we want to call attention to an invisible line, we dot it.

Work in the same manner, (1), (2), (3), fig. 159.

In the Book: Draw any of the foregoing or similar working drawings.

—— SECTION 36. ——

CONVENTIONAL LEAVES.

Each pupil should have:

1. A pair of scissors and a piece of thin paper.
2. Several leaves of the same kind (ivy, maple, lilac, etc.) Select them with their opposite edges as nearly alike as possi-

ble. The leaves should be pressed between the pages of a book, a few days in advance.

Trace the *left half* of the leaf, leaving out the small details; then, reverse the leaf, and make the *right half* exactly like the *left half*. Take the leaf off. Correct irregular outlines, and put in the principal veins only. You have made a new form from the natural one. This new leaf is called a *conventional leaf*.

RULE: To conventionalize a form is to omit everything that can be omitted, and still express the leading features and habits of the object represented.

Examine samples of wall-paper, carpets, etc. Find what parts of the designs in these articles are made from natural forms.

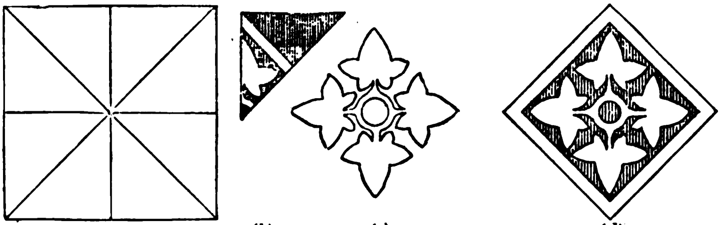

(a) (b) (c) (d)

Fig. 160.

(*a*) Fold a piece of paper upon its center until you have eight equal angles.

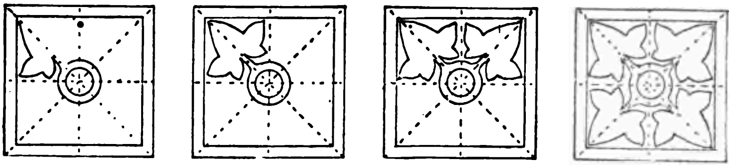
(*b*) Same folded, with left half of an ivy leaf drawn on it. Make the stem very slender. Cut off shaded surface.

(*c*) Same opened. It makes a rosette.

(*d*) Rosette with enclosing form.

Tracing: To save time, the practical decorator has different devices called tracing, pricking and pouncing, etc.

To trace fig. 161, for instance.


(a) (b) Fig. 161. (c) (d)

(a) Draw enclosing form (with instruments). Divide it into eighths. Draw ⅛ of the rosette. Over this, place a piece of transparent paper. With a soft pencil (HB or SM) trace the unit on transparent paper.

(b) Turn the tracing face down, and transfer to the next eighth by rubbing with the finger-nail, or any hard and smooth surface.

(c) Trace one-fourth of the rosette; rub it in the other blank spaces around the center of the square.

Correct mistakes; line in.

PRICKING AND POUNCING. Another method used in frescoing, in wall-paper, in embroidery, in carving, etc., is to fold some thin paper and to draw the unit upon it, as in (b), fig. 160. Then with a tracing wheel, or even with a common pin, prick the lines of the design, making a kind of dotted stencil. Spreading that stencil over the space to be ornamented, rub some powdered charcoal over it. This powder, passing through the openings of the stencil, will give a dotted re-production of the pattern.

Practice. Repeat this same exercise with a maple, lilac, or other simple leaf.

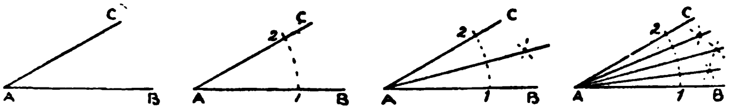
In the Book: Draw a rosette. Select an enclosing form, Section 29. You may use a colored crayon.

CHAPTER IV.

SECTION 37.

ANGLES. PROTRACTOR.

Problem 34. To bisect a given angle.



(a) (b) (c) (d)

Fig. 162.

(*a*) Rule angle A.

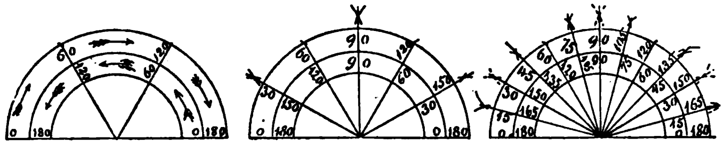
(*b*) With any radius, center A, describe arc 1-2.

(c) Bisect arc 1-2.

(*d*) Same angle, divided into fourths.

Can you bisect obtuse angles ?

Application. To divide a circle into sectors of 15 degrees each



(a) (b) (c)

Fig. 163.

(*a*) Semi-circle (radius 2," or 3"). Divide into thirds. Write figures 0, 60, 120, 180.

(*b*) Bisect 60 degree sectors. Write 30, 90, 150.

(*c*) Bisect 30 degree sectors. Write 15, 45, 75, 105, 135, 165.

Draw the division lines from the center of the semi-circle.

Protractor. A protractor is a circle, or a semi-circle, divided into degrees, minutes, etc. The protractor is used to measure the size of angles: *i. e.*, the difference of direction of the two sides of an angle.

Sometimes the edges of protractors are cut into different shapes.

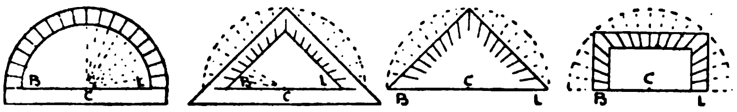


Fig. 164.

(*a*) (*b*) Protractors with part of the inner suface left open.

(*c*) (*d*) Protractors without open spaces.

In all of them, B L means *base line*; C, *center.* The degrees are marked either upon the inner or upon the outer edges of these instruments.

To measure an angle, place the **base line** of the protractor **upon one of the sides of the angle,** and its **center** exactly upon the **vertex** of the same angle; then, count, upon the edge of the protractor, the number of degrees between the two sides of the angle.

Problem 35. To draw an angle of a given number of degrees, with the protractor. Angle, 45 degrees.

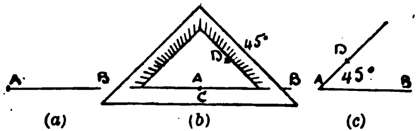


Fig. 165.

(*a*) Draw A B.

(*b*) Place the center of the protractor upon A, and its base upon A B. Mark off point D, exactly opposite line 45 on the right side of the protractor.

(*c*) Removing the protractor, draw line A D, which ought to make an angle of 45 degrees with A B.

Can you draw the following angles in the positions given in fig. 166?

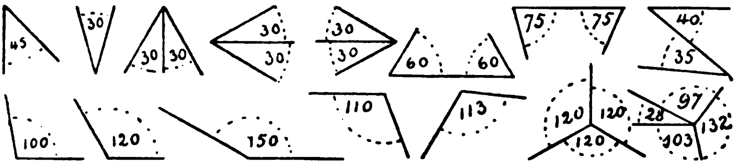


Fig. 166.

The **lengths** of the sides of an angle have **nothing to do with the difference in direction** of these same lines, (sides).

—— SECTION 38. ——

ANGLES. PROTRACTOR.

Problem 36. With the protractor, to find the number of degrees in a given angle.

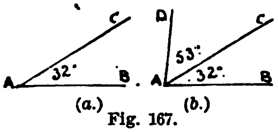
Draw any angle. Place the protractor as in Problem 165.

Write the number of degrees and fractions of a degree as far as practicable.

Draw acute and obtuse angles; find the number of degrees in each.

Problem 37. To draw two given adjacent angles. (32 and 53 degrees, for instance.)

Adjacent angles are angles so situated as to have a common vertex on one common side. (*b*) fig. 167.



(a.) Fig. 167. (b.)

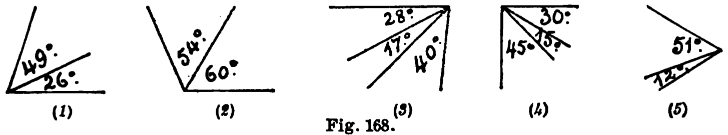
(*a*) Draw angle A B, A C, 32 degrees.

(*b*) Taking A C as one of the sides of the other angle, draw A D, making 53 degrees with A C.

Prove by finding the sum of the degrees in both angles. It must be 85 degrees exactly.

This suggests another method: that of drawing at once an angle of 85 degrees and dividing it into angles of 32 and 53 degrees.

Draw the adjacent angles of:



(1) (2) (3) (4) (5)

Fig. 168.

In the Book: Draw four of the foregoing problems.

—— SECTION 39. ——

TANGENT LINES. MOULDINGS.

RULE: When a **line** and a **circle** are **tangent,** the line is **perpendicular** to the radius of the circle, at the **point of contact.**

Problem 38. With a given radius, to describe a circle tangent to a point in a given line.

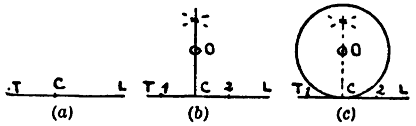


Fig. 169.

(*a*) Draw line T L, and point of contact C on the line.

(*b*) Erect a perpendicular at C; set off 10″, from C to O.

(*c*) With O as a center, O C as a radius, describe the tangent circle.

Problem 39. To draw a line tangent to a given circle, at a given point in the circumference of that circle.

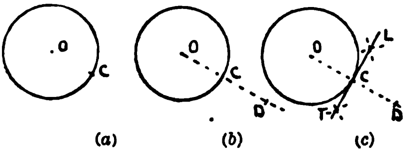


Fig. 170.

(*a*) Describe the given circle with the proper radius (10″ for instance). Draw the point of contact, C.

(*b*) Through O C, draw radius R extended. Make C D equal to C O.

(*c*) Bisect O D. Line T L is the tangent required.

APPLICATIONS.

Several mouldings are made from the circle tangent to a line or to another circle. The most common are:—

1. The **bead** or **astragal**, fig. 171, and the **torus**, fig. 172.

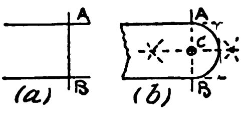


Fig. 171.

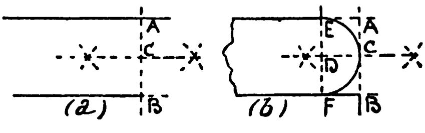


Fig. 172.

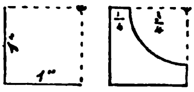
Bead. (*a*) Draw the parallel lines, and the perpendicular A B, in order to have the height of the moulding.

(*b*) Bisect A B; from center C, describe the arc A B.

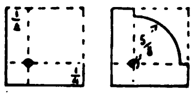
Torus, fig. 172. (*a*) Draw parallel lines, and perpendicular A B. Bisect A B.

(*b*) Set off A C in A E and in B F. Draw E D F. From center D, radius D E, describe E C F.

The Torus is generally larger than the Bead, and is used only in the bases of vases, columns, etc.



(a) Fig. 173. (b)



(a) Fig. 174. (b)

2. The **Cove** or **Cavetto** moulding, fig. 173.

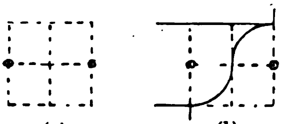
3. The **Quarter Round** or **Ovolo** moulding, fig. 174.

In the Book: Draw, with instruments, all the foregoing figures.

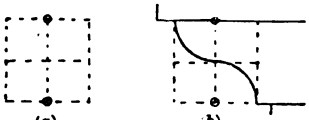
SECTION 40.

MOULDINGS. (Continued.)

4. The **Cyma Recta,** figs. 175 and 177, and the **Cyma Reversa,** figs. 176 and 178.

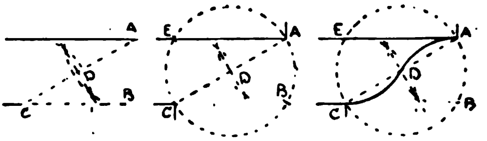


(a) Fig. 175. (b)

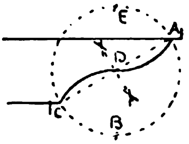


(a) Fig. 176. (b)

At 30 degrees.



(a) (b) (c)
Fig. 177.



(d)
Fig. 178.

(*a*) Draw parallel lines A and B. Draw line A C, at an angle of 30 degrees with A. Bisect A C.

(*b*) Radius A D, center D, describe a circle. With the same radius, centers A and C, describe arcs E and B.

(*c*) Same radius, centers E and B, describe arcs C D and D A.

(*d*) For the cyma reversa, reverse the centers, and leave a small projection above and another below the moulding, at A and C.

5. The **scotia,** figure 179.

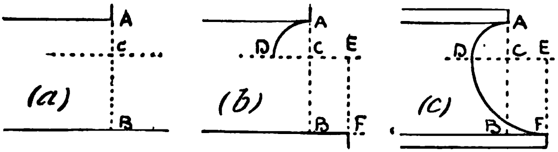


Fig. 179.

(*a*) A B the height of the scotia. Divide it into **two unequal** parts. Through the point of division C, draw a line perpendicular to A B.

(*b*) Center C, radius C A, describe arc A D. Set off the remainder of the height, C B, from D to E. Draw perpendicular E F.

(*c*) Center E, radius E D, describe arc D F.

If you can procure the above mouldings, measure them, and draw them full size.

When the curves are too small, draw them free hand.

In the Book: Draw several of the foregoing examples.

SECTION 41.

DECORATION.

CENTERS. CONSTRUCTION LINES.

A **center** should be more prominent than the corners and marginal lines. It represents the stalk of the plant and the source of growth. It should overlap the units, binding them strongly together.

The enclosing forms in Section 29 may be used as centers, after being reduced in size.

Usually the center and the enclosing form of a rosette have the same number of sides. Oblongs, rhombuses, and ellipses harmonize together. A circle agrees with any regular polygon.

Geometrical Divisions. Avoid extremes. Do not divide the space into too large, too small, or too many parts.

Do not place very large and very small parts close together, but let their differences be gradual.

In the Book: (*a*) Select one of the enclosing forms in Section 29, or invent one.

(*b*) Draw the marginal bands, center, and main lines.

(*c*) Conventionalize a leaf for a unit.

(*d*) Arrange that unit for a rosette.

(*e*) Half-tint the uncovered parts of the background.

—— SECTION 42. ——

PAPER MODEL OF A CYLINDER.

The covering of a cylinder consists of three pieces:—two equal circles, for its bases, and a rectangle for its lateral surface.

Make a paper model of a cylinder; height 2½″, and diameters of bases 2″ each.

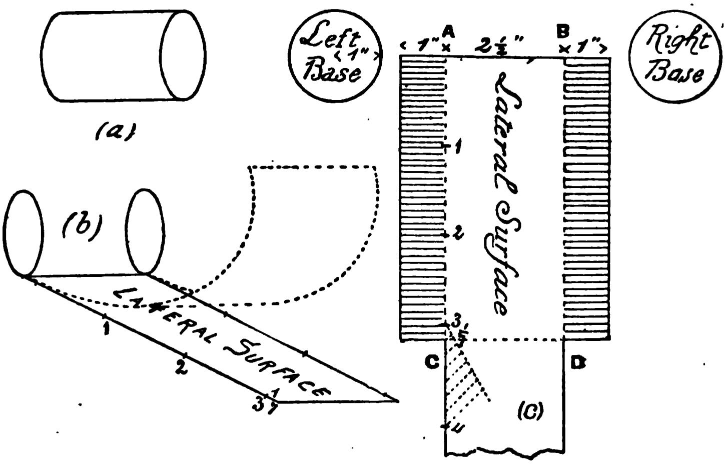


Fig. 180.

(*a*) Cylinder. (*b*) Unfolding. Bases. Lateral surface. The length of the lateral surface must equal the length of the circumference of the circle of one of the bases. The diameter being $3\frac{1}{7}$ times the circumference of its circle, the length of the lateral surface must also be $3\frac{1}{7}$ times the length of the diameter of one of the bases.

(*c*) Right and left bases. Lateral surface. Draw A B and perpendicular lines A C, B D, 2½" apart. From A and B, set off four diameters (four times two inches) in 1, 2, 3, and 4. Divide the last part into sevenths. Draw line C D.

Mounting. Add paper about one inch on each side of the lateral surface. Fold the model on line A C, B D, but **not on line** C D.

Cut the paper added on each side into *very fine* strips.

Put inside of the model all the paper below C D, bringing A B exactly over C D. Paste.

Fold and paste the small strips on the sides. When these are dry, past the bases carefully.

This model may be improved by making it with double bases, *i. e.*, putting cardboard circles inside of the solid, and pasting the small strips upon them; then paste the real bases over the strips so that the latter is not seen. Make these inner circles slightly smaller than the bases.

SECTION 43.

PAPER MODELS.

ASTRAGAL, OVOLO, AND CAVETTO.

These models are made like the cylinder and other prisms

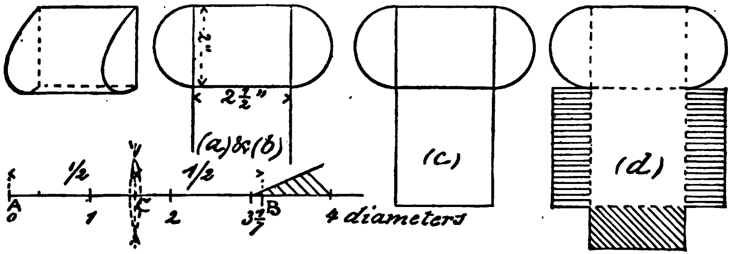


Fig. 181.

(*a*) Left base, 1½ radius. Bottom 2½". (*b*) Right base. (*c*) Lateral surface added. Find the length of the circumference of a circle having a three inch diameter.

Bisect the length of that circumference for an astragal or for a torus; quartersect that length for an ovolo or for a cavetto. (*d*) Ready for mounting.

Work in the same manner:

The Ovolo:

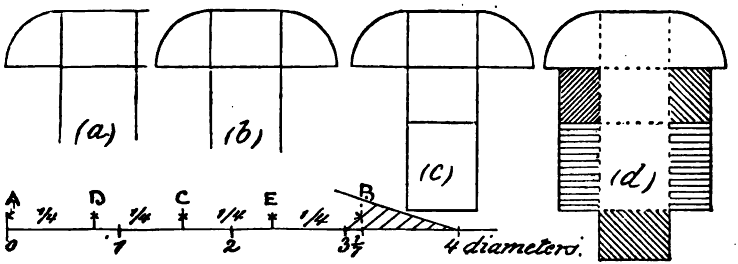


Fig. 182.

The Cavetto:

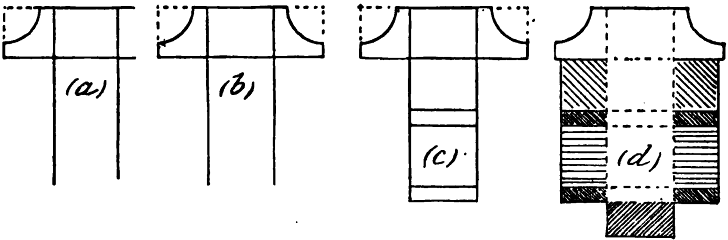


Fig. 183.

The same and similar models may be made of clay, soap, plaster, soft wood, etc., or procure these mouldings from a planing mill, and cut them 2″ or 3″ in length; give each pupil a piece of every moulding.

Colored paper models may be pasted in the book. In this case omit the extra surface for folding.

SECTION 44.

OBLIQUE PROJECTION.

CYLINDER. BASES FRONT AND REAR.

When the bases of the cylinder face **front** and **rear** they are drawn as **circles**, but when they face **up** and **down**, **left** and **right**, they are represented by **ellipses**.

NOTE. As far as practicable place the bases of cylinders *front* and *rear*. However, it is sometimes necessary to use the other positions, as when the wheels, axles, etc. of the same machine are turned in different positions.

Draw **very** rapidly. You may use compasses.

To draw a cylinder, 1′ 6″ base by 2′ 8″ long. One inch scale. Bases front and rear. Station 7.

FIRST METHOD.

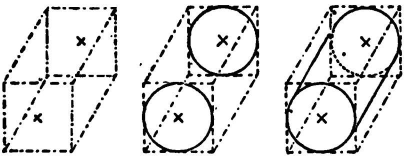

(a) (b) (c)

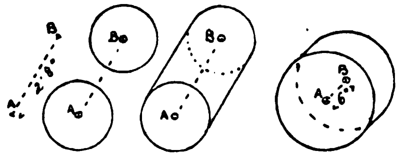
Fig. 184.

(*a*) Construct a square prism 1′ 6″ x 1′ 6″ x 2′ 8″ Find centers of squares.

(*b*) Describe circles for the bases of the cylinder.

(*c*) Draw tangent lines.

SECOND METHOD.



(a) (b) (c) (a)

Fig. 185.

(*a*) Draw center line A B, 2′ 8″ long. Any desired slant.

(*b*) With a 9″ radius, describe two equal circles from centers A and B.

(*c*) Draw tangent lines.

Line in *only* the lines or parts of lines that can be seen.

(*d*) When the bases are close together their circles intersect each other.

Work in the same manner:

The **Bead (or Astragal)** and the **Torus.**

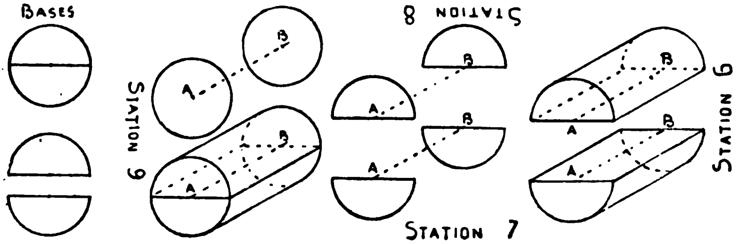


Fig. 186.

Turn these figures about, in front of your eye, to see them in different positions, and at different stations.

Find these mouldings on doors and windows; bases of vases, columns, etc. They are often accompanied by fillets, plinths, etc.

In the Book: Draw four views of the foregoing solids.

—— SECTION 45. ——

OBLIQUE PROJECTION. OVOLO. CAVETTO. ETC.

Use ruler, triangle, compasses; or draw **rapidly,** free hand:—

Ovolo or **Quarter Round.**

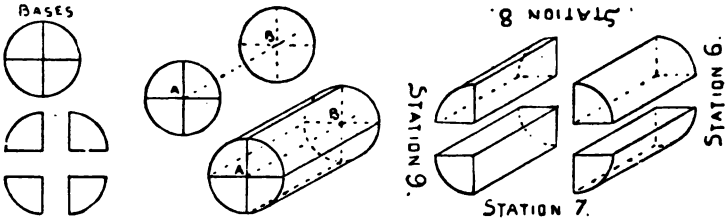


Fig. 187.

Turn your work about, to have different views of it.

Find this moulding on doors, windows, furniture, etc., with or without other mouldings.

Cavetto.

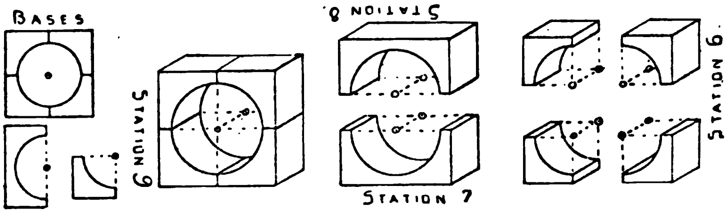
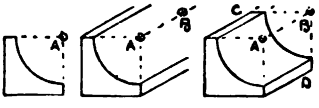


Fig. 188.

With instruments. (General method for all mouldings.)



(a) (b) (c)
Fig. 189.

(*a*) Draw first base. (*b*) Add parallel lines (Ruler and Triangle). Draw B at a distance from A equal to the distance between the front and the rear. (*c*) Draw lines B C, B D, and the visible lines of the second base.

Cymas, Scotia, Regular Hexagonal Prism. Work in a similar manner:

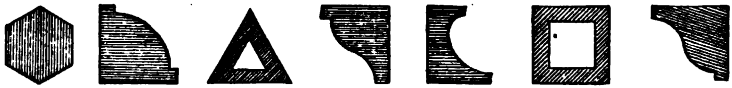


Fig. 190.

In the Book: With instruments, draw views of the different mouldings in this section.

—— SECTION 46. ——

FREE HAND SKETCHES OF MOULDINGS.

Draw rapidly, free hand.

Try to imitate the proportion given to the different mouldings. To avoid monotony, mouldings should differ in size. Of the mouldings treated in this book, the fillet and the bead are the smallest; the cavetto, the ovolo, and the cyma reversa come next; then the cyma recta, the scotia and the plinth.

How to proceed:—

(1.) Draw the front base.

(2.) Draw the oblique lines according to the station at which the object is placed.

(3.) Make all the oblique lines of the same length. Draw the visible lines of the rear; these lines should be parallel with the corresponding lines in the front.

(4.) When the sketch is lined in, turn it about, to have different views of it.

Bases:

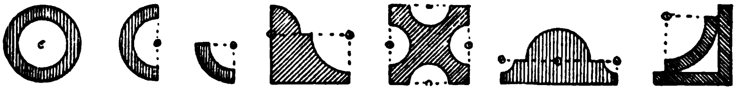


Fig. 191.

At Station 7:

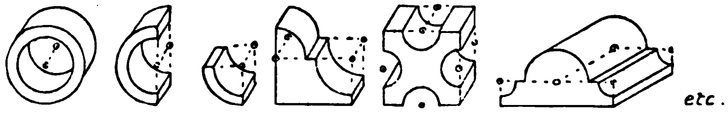


Fig. 192.

Draw the same at all stations.

Work in the same manner:

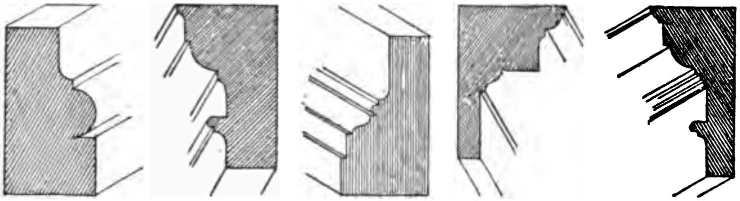


Fig. 193.

Find other sets of mouldings. Copy from cornices, bases, and other details of houses, etc.

In the Book: Free hand, draw a few of the foregoing, or similar mouldings copied outside. In this case, write the number of the house, the name of the street, etc., from which the set of mouldings has been taken.

SECTION 47.

PLANS AND ELEVATIONS OF MOULDINGS.

Do not work this Section without having the proper models in your hands.

Procure as many mouldings as possible of the following or of similar bases or ends:

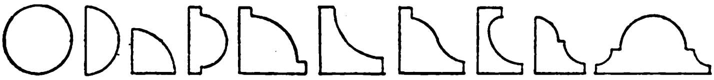


Fig. 194.

Review briefly Sections 33, 34, and 35, particularly how to *see* plans and elevations.

Draw the working drawings of any moulding, bases front and rear. A cavetto, for instance:

(1.) Draw its front view or front elevation. (*a*) Fig. 195.

(2.) Draw its top view or plan. (*a*) Fig. 195.

(3.) Turn the base in other positions, (*b*), (*c*), (*d*), and draw the plans accordingly.

Work other mouldings in the same manner:

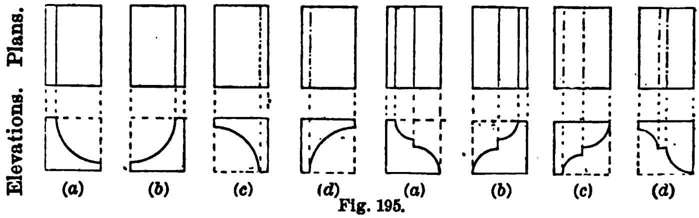


Fig. 195.

EXERCISES.

From analogy and imagination, make the working drawings of fig. 192.

2. At stations 6, 7, 8 and 9, draw the oblique projection of fig. 196.

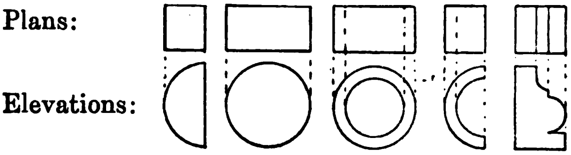


Fig. 196.

In the Book: Draw the oblique projection of any moulding or mouldings, and the working drawings of the same.

SECTION 48.

DECORATION.

UNITS. ALL-OVERS OF THE SQUARE PATTERN.

Units of Design. 1. Do not use too few or too many ornaments. Even with the most graceful lines, excessive repetition brings monotony, a mistake often made in carpet and in wall patterns.

2. Do not draw units too large or too small for the ground to be filled.

3. Do not place small units in the angles of the enclosed space, and then try to connect them with the center by long stems or lines.

4. Avoid weak centers, heavy corners, and large intermediate spaces unfilled. The unfilled spaces should be rather towards the edges than towards the center. Generally, the units should not touch the geometrical enclosing lines.

5. Alternating two or more units is more pleasing than using a single unit.

Background. (1) The background should always attract *less* attention than the design itself.

(2) **Half tint.** Whichever covers the least surface, the background or the ornament, should be tinted. Where there is more half-tint than white surface, the design is likely to appear heavy.

The background may be: (1) Plain and smooth. (2) Tinted. (3) Rough. (4) With subdued designs or colors.

All-overs. Square Pattern. The frames for all-over patterns are very few. The most common frame is the square.

FIRST METHOD.

(1) With instruments, draw a number of small squares.

(2) Considering the intersections of the lines as points, connect these points by new lines; Ex:

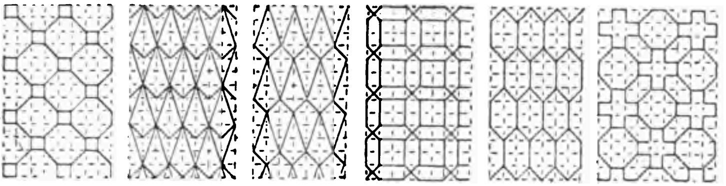
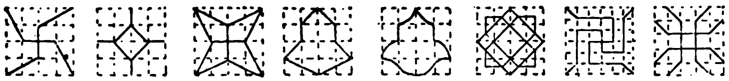


Fig. 197.

SECOND METHOD.

(1) Draw a number of squares larger than in the first method.

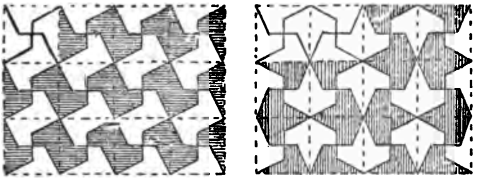
(2) Select a unit of design from the following, or invent one having a few lines only, (1) fig. 198, for instance:



(1) (2) (3) (4) (5) (6) (7) (8)

Fig. 198.

(3) Draw the selected unit in each square, (*a*) fig. 199.
The same unit reversed in each alternate square, (*b*) fig. 199.



(*a*) (*b*)

Fig. 199.

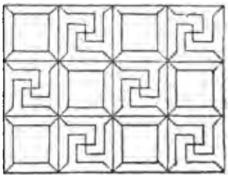


Fig. 200.

The unit may also be drawn in every second square, alternating with a blank square or a less complicated unit, fig. 200.

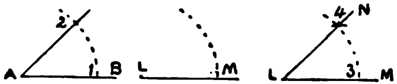
In the Book: Draw one all-over pattern for an oilcloth, inlaid wood, or mosaic.

CHAPTER V.

SECTION 49.

ANGLES, SQUARES, ETC.

Problem 40. With compasses (**no protractor**), to draw an angle equal to a given angle.



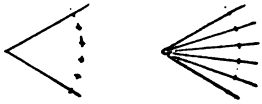
(a) (b) (c)
Fig. 201.

(*a*) Draw any angle, A.

(*b*) Draw L M, side of the second angle. With any radius, centers A and L, describe equal arcs.

(*c*) Set off 1-2 of (*a*) in 3-4 of (*c*), and draw line L N.

Problem 41. To divide an angle into any number of equal parts. Into fifths, for instance:

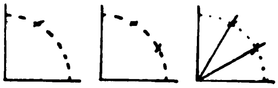


(a) Fig. 202. (b)

(*a*) With any radius, the vertex of the angle as a center, describe an arc. With dividers, by trial, divide the arc into fifths.

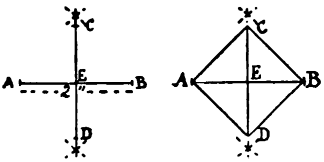
(*b*) Connect the points of division with the vertex.

With compasses, divide a right angle into thirds:



(a) (b) (c)
Fig. 203.

Problem 42. To construct a square, its diagonals being given. Diagonal 2″.

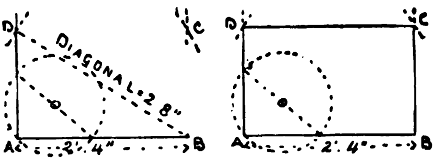


(a) Fig. 204. (b)

(*a*) Draw diagonal A B. Bisect it.

(*b*) Set off E A (half diagonal) in E C and in E D. Connect.

Problem 43. To construct an oblong, its diagonal and one of its sides being given. Diagonal 2′ 6″; side 2′ 4″.

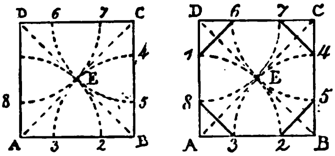


(a) F.g. 205. (b)

(*a*) Draw side A B, (2′ 4″ long). Erect perpendicular at A. With radius 2′ 8″, center B, describe arc in D; same radius, center A, describe arc in C. Set off A B in D C.

(*b*) Connect D C.

Problem 44. To inscribe a regular octagon within a given square. Square 2′ 3″.



(a) Fig. 206. (b)

(*a*) Construct the square, and draw its diagonals. With A, B, C, and D as centers, and a radius equal to A E (½ of diagonal), describe arcs 1-2, 3-4, 5-6, 7-8.

(*b*) Connect 8-3, 2-5, 4-7, and 6-1.

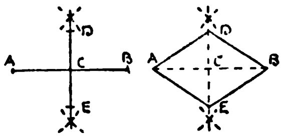
By this method the ends of square posts may be changed into regular octagons. Square tiles may be cut so as to make a floor of square and octagonal figures, etc.

In the Book: Draw a few of the foregoing problems.

SECTION 50.

THE RHOMBUS.

Problem 45. To construct a rhombus, its diagonals being respectively 2′ and 3′.



(a) (b)

Fig. 207.

(*a*) Bisect A B, the 3′ diagonal. From C set off ½ of the short diagonal in D and in E.

If, instead of feet and inches, a line is given, bisect it separately to find its half.

(*b*) Connect A and B, with D and E.

Problem 46. To construct a rhombus, a diagonal and a side being given. A B, diagonal; A C, side.

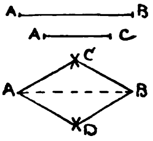


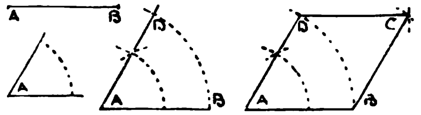
Fig. 208.

(*a*) Draw the diagonal; with a radius equal to the length of the given side, centers A and B, describe arcs in C and D.

(*b*) Connect A and B, with C and D.

This example is like drawing an isosceles triangle on each side of a line.

Problem 47. To construct a rhombus, an angle and a side being given.



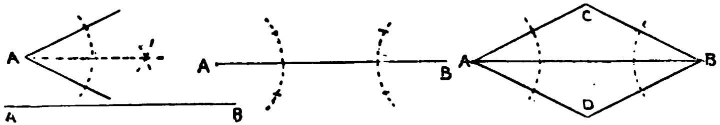
(*a*) (*b*) Fig. 209. (*c*)

(*a*) Given line and given angle.

(*b*) Make an angle equal to the given angle. Set off the length of the given side from A to B, and A to D.

(*c*) With the same radius, centers B and D, describe arcs in C. Connect.

Problem 48. To construct a rhombus, an angle and a diagonal being given.



(*a*) (*b*) (*c*)
Fig. 210.

(*a*) Given angle and given diagonal. Bisect the given angle.

(*b*) Draw the diagonal A B. At A and B, draw ½ of the given angle on each side of the diagonal.

(*c*) Extend the lines until they meet in C and D.

In the Book: Draw examples similar to each of the foregoing problems.

—— SECTION 51. ——

THE ELLIPSE.

"An **Ellipse** *is a plane figure bounded by a curve, every point of which is at the same combined distance from two points called* **foci.**"

TERMS: A B, major axis. C D, minor axis. E, center. F, focus. G, focus (plural: foci). H, one of the points on the elliptical curve, (*c*) fig. 211.

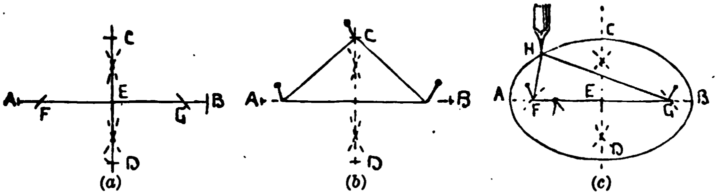
If the major axis is two feet long, the combined distance from point H to the foci F and G is also two feet.

Therefore, to find the foci of an ellipse :—

(1.) Draw the major and the minor axis, bisecting each other at right angles.

(2.) From one of the ends of the minor axis (either C or D), with one-half of the major axis as a radius, describe arcs in points F and G.

Problem 49. Its axis being given, to describe an ellipse with needles and thread.



(*a*) (*b*) (*c*)

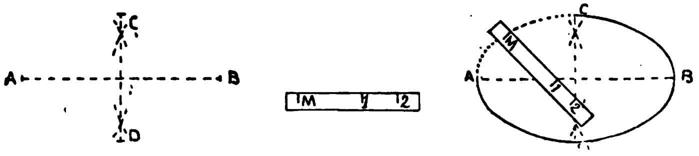
Fig. 211.

(*a*) Bisect the major axis, A B. Set off $\frac{1}{2}$ the minor axis in E C, and in E D. With radius A E, center C, describe arcs in F and G (foci).

(*b*) Stick *very fine needles* at points C, F, and G. Tie a *fine thread* closely around the needles.

(*c*) Remove the needle at C. Press a pencil point against the thread, carrying the pencil around without touching the needles. If performed with skill, the elliptical line should pass through A, C, B, and D.

Problem 50. The axes being given, to describe an ellipse with a strip of paper.



(*a*) (*b*) (*c*)

Fig. 212.

(*a*) Axes. (*b*) On a slip of paper having a straight edge, draw: (1) M, the marking point. (2) M 1, equal to one half of the minor axis. (3) M 2, equal to one half of the major axis.

(*c*) Move the paper, always keeping point 1 upon the major axis, and point 2 upon the minor axis. In every new position, mark the place of the point M; and, when a sufficient number of these points have been drawn, describe the curve free hand. The nearer the points are to each other, the easier it is to describe an accurate ellipse.

In the Book: Describe ellipses by both methods.

Applications: Mirror frames, passe-partouts for photographs, flower beds, etc.

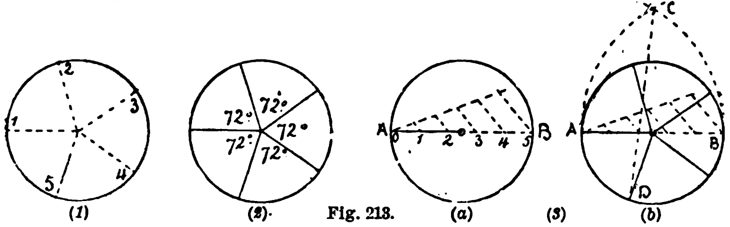
To trace an elliptical flower bed, substitute stakes for the needles.

—— SECTION 52. ——

DIVISION OF THE CIRCLE, ETC.

Problem 51. To divide the circumference of a circle into any number of equal parts. Into fifths, for instance.

(1.) With dividers. (2.) With a protractor. (3.) By a geometrical operation.



(1) (2) Fig. 213. (a) (3) (b)

(1.) Use the dividers as for straight lines. See Section 16.

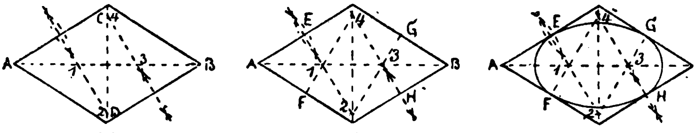
(2.) Divide 360 degrees by 5. Set off angles of 72 degrees with the protractor.

(3.) (*a*) Divide the diameter, A B, of the given circle into fifths. (Problem 9, Section 5).

(*b*) With radius A B, centers A and B, describe arcs in C. Draw line C D, passing through the second point of division. Arc A D is $\frac{1}{5}$ of the circumference. With A D, divide the circumference into fifths.

Whatever the number of divisions may be, **always** draw line C D through the **second point** from A or B on the diameter.

Problem 52. To describe an oval tangent to the four sides of a rhombus.



(a) (b) (c)

Fig. 214.

(*a*) Construct a rhombus. Draw its diagonals. It is sometimes necessary to extend the short diagonal beyond C and D. Bisect two of the opposite sides of the rhombus.

(*b*) Draw lines 4 1 F and 2 3 G.

(*c*) Radius 1 E, centers 1 and 3, describe arcs E F and G H. Radius 2 E, centers 2 and 4, describe arcs E G and F H.

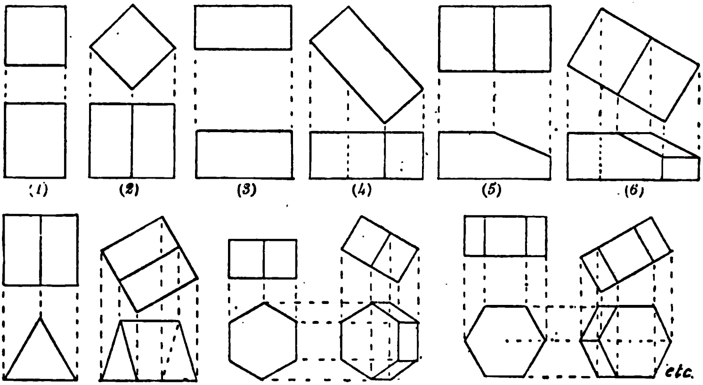
In the Book: Draw problems similar to the foregoing.

—— SECTION 53. ——

PLANS AND ELEVATIONS OF PRISMS.

MODELS: A cube, square, and other prisms for each pupil.

Place them in the following positions, and draw their plans and elevations:



(1) (2) (3) (4) (5) (6)

(7) (8) (9) (10) (11) (12)

Fig. 215.

In the Book: Draw plans and front elevations of the foregoing or other blocks. Turning the model a little to the right or to the left, draw the same plan obliquely and with a new elevation. **Do not** draw any line of which you do not understand the meaning.

—— SECTION 54. ——

DECORATION.

Steps in making a Design. Make a rough free hand sketch on slate or blackboard; then, with instruments and free hand, draw successively on paper:

(1.) The enclosing form. (2.) Its divisions. (3.) The main lines and axes of the units. (4.) The units. (5.) Clean the paper, and line in.

Rules in Decoration. The vital part of a design is in its main lines, particularly if the unit is from a plant. Those main lines should represent the proper growth: i. e. distribution of leaves, buds, flowers, etc. of that plant.

Do not draw weak stems; they should never be drawn with a single line. Sketch *only* the *principal veins* of a leaf.

One of the chief essentials to good elementary design is *flatness*.

Block in the general shape of a leaf or flower first, then draw the details. Never draw the details first.

No form, or line for which we cannot give some good reason or explanation to be, should be allowed to remain in a design.

Plans and elevations of flowers. Bring to school simple flowers; as, lilac, morning glory, buttercup, periwinkle, etc.

Conventionalize one of them, drawing its elevation and plan as you would do with a block or moulding.

Work the buds, leaves, etc., in the same manner.

If you cannot procure a suitable flower, select your units from the following conventionalized plants: the convolvulus, the mallow, and the cranesbill.

MATERIALS FOR DESIGN.

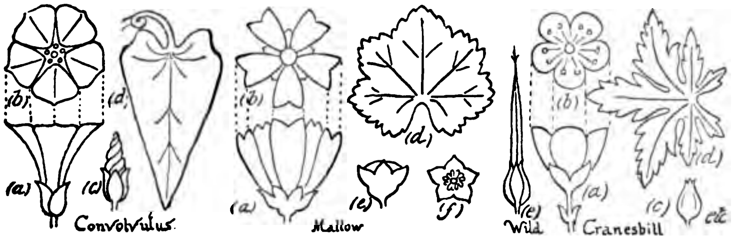


Fig. 216.

(*a*) Elevation of flower; (*b*) plan of flower; (*c*) bud; (*d*) leaf; (*e*) seed; (*f*) calyx.

In the Book: Following the rules given at the beginning of this section, design a rosette, a panel, or a border.

For enclosing forms, see Section 29.

—— SECTION 55. ——

OBLIQUE PROJECTION.

BASES OF CYLINDERS FACING UP AND DOWN, ETC.

Viewed obliquely a circle appears as an ellipse.

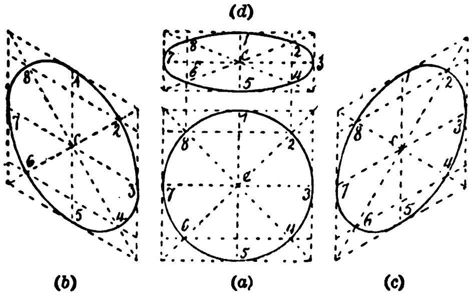


Fig. 217.

(*a*) Describe circle. Enclose it within a square. Draw the diagonals and the diameters, cutting the circle in points 1, 2, 3, 4, 5, 6, 7, and 8.

(*b*), (*c*) and (*d*) same circle viewed obliquely. The elliptical line should pass through points 1, 2, 3, 4, etc. In (*b*) and (*c*) the real axes of the ellipses are from 2 to 6, and from 4 to 8.

To have oblique bases of cylinders in all positions, turn figure 217 about.

The following method is often used:

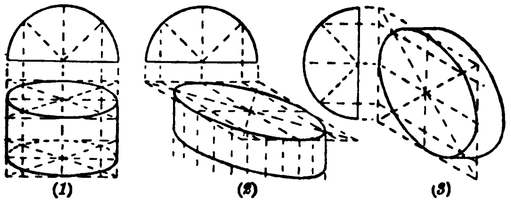


Fig. 218.

(1.) Cylinder: Draw first the upper and then the lower base.

(2.) Cylinder: Draw a number of parallel lines, and set off on each of them the distance between the bases; then connect the points.

(3.) Cylinder: Keep the outline of the right base parallel with that of the left base.

In the Book: Draw, either figure 217 or 218.

—— SECTION 56. ——

OBLIQUE PROJECTION.
HALF AND QUARTER CYLINDERS.

Free hand and instrumental; work as in last section.

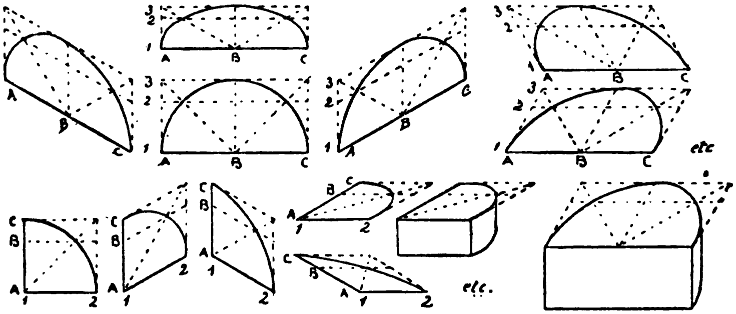


Fig. 219.

Turn the figure on its sides, for upper and lower bases.

Follow general methods for prisms, Sections 10 and 11. Free hand, or with instruments:

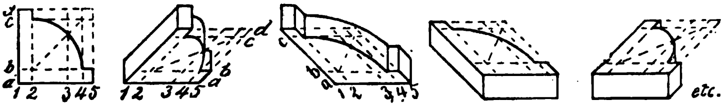


Fig. 220.

In the Book: Draw a few sketches of the foregoing or similar mouldings.

SECTION 57.

OBLIQUE PROJECTION. HOLLOW CYLINDERS, ETC.

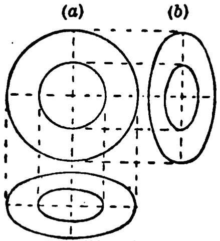


Fig. 221.

Viewed obliquely, concentric circles appear as in (*b*) and (*c*), fig. 221.

Observe that the lines of the ellipses in (*b*) and (*c*) are not parallel.

Free hand, with instruments, or both, draw rapidly and lightly, as in last section:

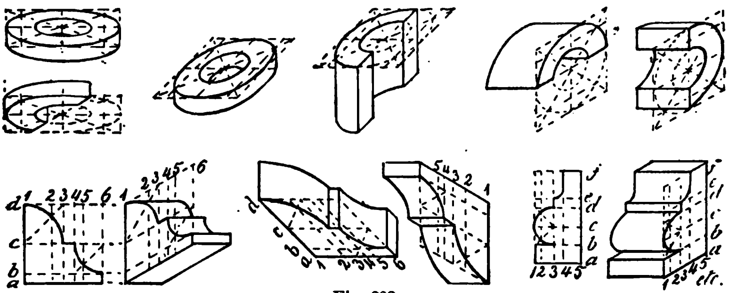


Fig. 222.

Find other sets of mouldings, and draw them in the same manner.

In the Book: Copy several mouldings in different positions, and at different stations.

SECTION 58.

PLANS AND ELEVATIONS OF MOULDINGS.

Review briefly, Sections 33, 34, 35, and 47.

Do not work without the proper models—such as those used in Section 47.

When the bases are right and left, draw a side elevation first, (*a*) and (*c*), fig. 224.

Place the following mouldings in positions shown in fig. 223 and fig. 224; draw the same:

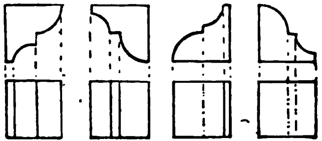


Fig. 223.

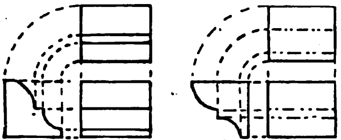


Fig. 224.

In the same manner, draw the plans and elevations of other mouldings, placed in as many positions as possible.

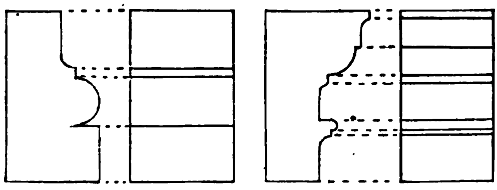


Fig. 225.

Sometimes the plan is omitted, the drawings being complete enough with the front and side elevations. Fig. 225.

In the Book: Draw the oblique projection of any set of mouldings; then, draw their plans and elevations. Bases facing up and down, right and left.

*Abbreviations: Pl., plan. F E, front elevation. S E, side elevation.

SECTION 59.

FREE HAND CURVES.

NOTE. Do not draw every example in this Section.

RULES FOR THIS EXERCISE.

1. There should be no re-drawing on the line, no rubbing, no breaks in sketching.

2. Use the **shoulder** movement. Draw on a **large** scale, examining the work often at a distance.
3. Be careful to have **all** the lines **tangent.**
4. Draw each example in several positions, or around a center.

Work rapidly:

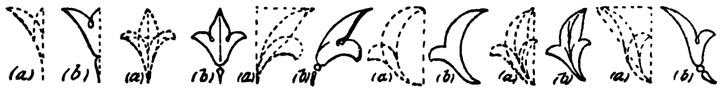


Fig. 226.

Draw rapidly both sides of any of the following bi-lateral forms.

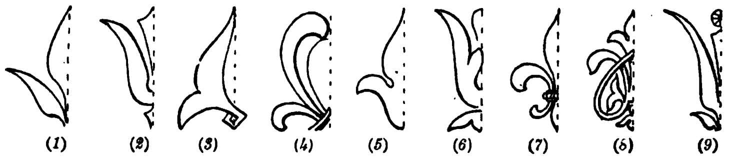


Fig. 227.

In the Book: Draw several of the above or similar forms; or, fold, cut and paste pieces of colored paper of the same shapes.

SECTION 60.

SCROLLS.

Models: Make the models for this lesson by rolling slips of stiff paper, or pieces of tin, etc.

Scrolls are worked like other prisms:

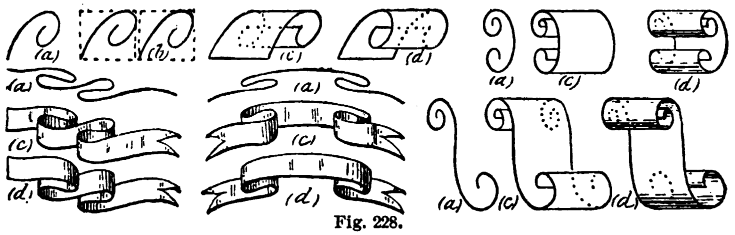


Fig. 228.

(*a*) Draw the visible base.

(*b*) Draw the outline of the second base parallel with the outline of the first.

(*c*) Connect the two bases. Line in only the edges seen.

(*d*) Back of scroll.

With instruments:

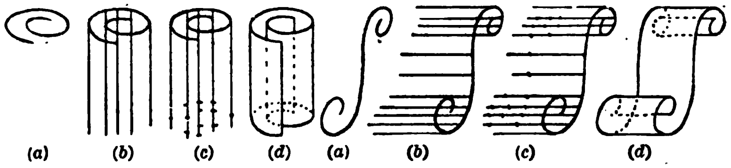


Fig. 229.

(*a*) Draw the base.

(*b*) At random, draw parallel vertical lines.

(*c*) From each point on the base, crossed by vertical lines, set off the distance between the two bases.

(*d*) Strengthen the lines that are seen.

Work the next scroll in the same manner.

In the Book: 1. Sketch a **waving flag.** Notice first how a real flag looks when waving, and sketch one of its edges, or, 2. Make a **roll of honor** with a base similar to (*c*) or (*d*); fig. 228.

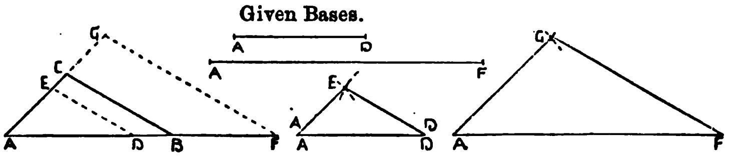
CHAPTER VI.

SECTION 61.

ENLARGING AND REDUCING.

Problem 53. A polygon being given, to construct similar ones on: (1) smaller, and (2) greater bases.

FIRST METHOD.

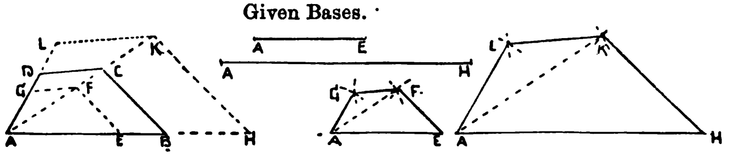


(a) Fig. 230. (b)

(a) Extend lines A C and A B on the given triangle. Mark off smaller base A D, and greater base A F. Draw lines D E and F G, each parallel to B C. This gives the two triangles required.

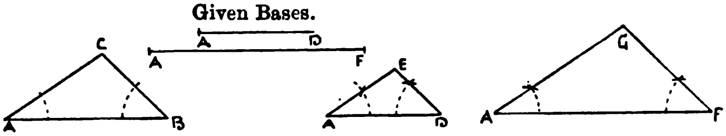
(b) Construct triangles with lines A D, D E, E A; and A F, F G, G A.

Work in a like manner :—



(a) Fig. 231. (b)

SECOND METHOD.



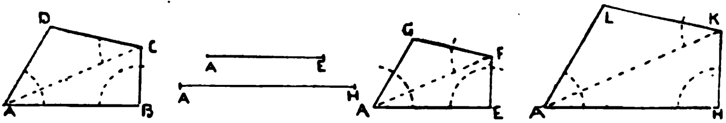
(a) Fig. 232. (b)

(*a*) Given polygon.

(*b*) **Transfer angles A and B to the extremities of bases A D and A F.**

Other polygons :—

Given Bases.



(*a*) Fig. 233. (*b*)

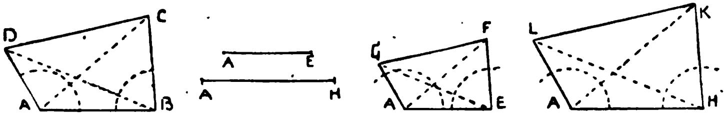
(*a*) Transfer angles A and B to bases A E and A H. Construct triangles A E F and A H K.

(*b*) Transfer upper adjacent angles, at A and C, to similar angles in the smaller, and in the larger polygon. Construct the second triangle of each figure.

THIRD METHOD.

Polygons of more than three sides :—

Given Bases.



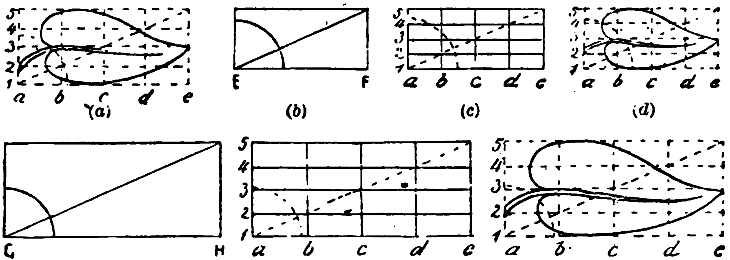
(*a*) Fig. 234. (*b*)

(*a*) Draw diagonals A C, B D.

(*b*) Transfer the adjacent angles at A and B of the given polygon, to the extremities of the given bases, A E and A H Connect points G F, and L K.

APPLICATION.

To enlarge or reduce any design :—



(*b*) (*c*) (*d*)
Fig. 235.

(*a*) Enclose the given design within a rectangle; divide it into two triangles, by drawing a diagonal; then divide the rectangle into any number of equal and similar parts.

(*b*) Transfer adjacent angles in (*a*) on bases E F and G H. Complete the rectangles.

(*c*) Divide each rectangle as in (*a*). Number and letter the vertical and the horizontal lines.

Copy into each division of the reduced or the enlarged rectangle that part of the drawing found in the corresponding division of the original figure.

Maps, ornaments, and patterns of all kinds may be enlarged or reduced in the same manner.

In the Book: Enlarge or reduce a map, a simple ornament, a leaf, etc.

SECTION 62.

CENTERS OF CIRCLES.

Problem 54. To find the center of a circle.

Notice that the bisecting line, O M, passes through the center of the circle from which the arc (or its chord A B) is taken. Fig. 236.

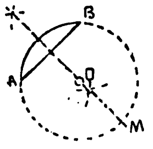


Fig. 236.

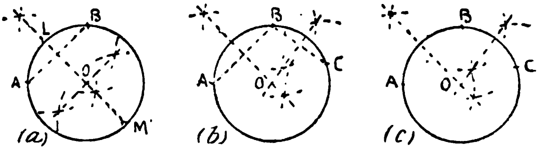


Fig. 237.

(*a*) Describe an arc with a given radius, then close the compasses. (Not to leave any mark indicating the center of the circle, place a folded piece of paper under the steel point of the compasses). Cut off an arc, A B, and bisect it. Bisect diameter L M. O is the center of the circle.

(*b*) **Another method.** Bisect two arcs, A B and B C. From point O as a center, radius O A, try the accuracy of this operation.

(*c*) Same simplified.

APPLICATIONS.

1. To describe a circle passing through three given points not in a straight line.

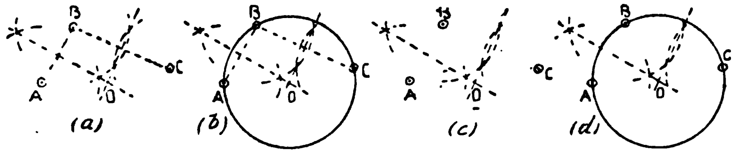


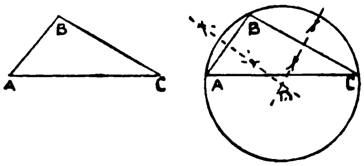
Fig. 238.

(*a*) Draw the given points A, B, C. Draw lines (chords) A B and B C; bisect them.

(*b*) From center O, radius O A, describe the circle (or arc).

(*c*) and (*d*) Omit the chords, and bisect spaces A B and B C.

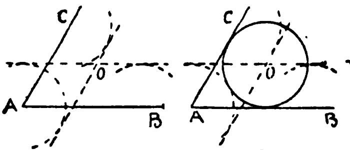
2. To circumscribe a circle about a given triangle. Fig. 239.



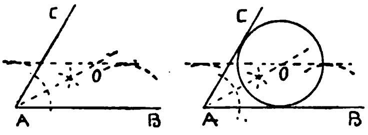
(*a*) Fig. 239. (*b*)

Lines A B, B C, and C A, of the given triangle, are chords of three arcs belonging to the same circle. Bisecting either two of these chords will give the center of the circle which necessarily will pass through points A B C.

Problem 55. To describe a given circle tangent to both sides of a given angle. Radius, 10″; angle 60, degrees.



(*a*) Fig. 240. (*b*)



(*c*) Fig. 241. (*d*)

(*a*) Draw the required angle. Draw lines parallel to A B and to A C, 10″ distant from each.

(*b*) With a 10″ radius, center O, describe the tangent circle.

(*c*) **Another method.** Bisect the given angle. Draw a line parallel to A B, and 10″ from it.

(*d*) From center O, radius 10″, describe the tangent circle.

In the Book: Draw a sample of each problem.

SECTION 63.

INSCRIBING CIRCLES.

Problem 56. To inscribe a circle within a given triangle.

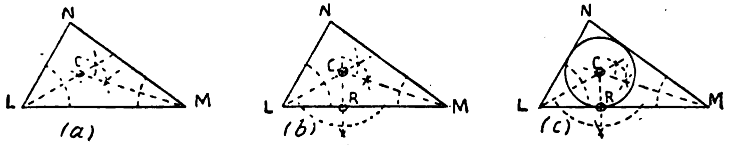


Fig. 242.

(*a*) Construct the given triangle; bisect two of its angles, to find center C.

(*b*) From C, let a perpendicular, C R, fall upon one of the sides of the triangle.

(*c*) With radius C R, center C, describe the tangent circle.

APPLICATIONS.

1. Inscribe a circle within a sector.

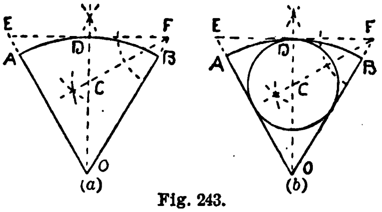


Fig. 243.

(*a*) Construct the given sector; bisect its angle O. At D, draw E F perpendicular to O D. Extend lines O A to E, and O B to F. This gives a triangle. Work as in last problem. Angle O being already bisected, bisect either angle E or F, to find center C.

(*b*) From center C, radius C D, inscribe the circle.

2. Inscribe six equal tangent circles within a given circle.

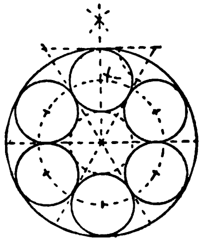


Fig. 244.

Divide the given circle into six equal sectors. Work as in last example.

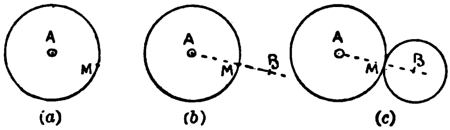
In the Book: Inscribe six equal tangent circles within a circle.

SECTION 64.

TANGENT CIRCLES.

To find the distance between the centers of two circles, **add** the **radii** when the **circles** are **tangent externally,** (*c*) fig. 245; **subtract** the short radius from the long one when the **circles** are **tangent internally,** (*b*) fig. 246.

Problem 57. To describe two **circles tangent externally** at a given point in the circumference of one of them. Radii 10″ and 7″ inches respectively.



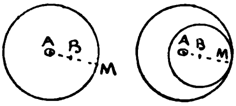
(*a*) (*b*) (*c*)
Fig. 245.

(*a*) With a 10″ radius, describe circle A; draw tangential point M.

(*b*) Draw indefinite line A M; from M set off 7″ (length of small radius).

(*c*) Radius B M, center B, describe the second circle tangent to the first at point M.

Circles tangent internally are treated in the same manner.

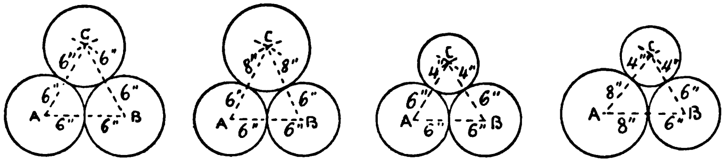


(*a*) Fig. 246. (*b*)

(*a*) Draw circle A, tangential point M, and indefinite line B M. Subtract radius B M from radius A M. The centers A and B are 3″ apart.

(*b*) From center B, radius B M, describe circle tangent at M.

Problem 58. To describe a given circle **tangent externally** to two other given circles.

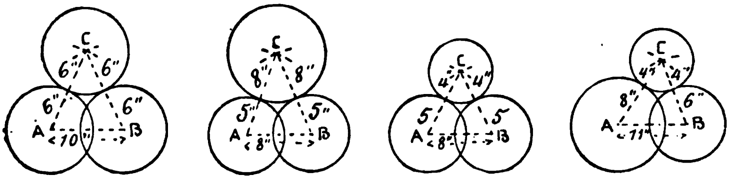


(1) (2) Fig. 247. (3) (4)

1. Find the distances between the centers. Construct a triangle: (1) equilateral; (2) and (3) isosceles; (4) scalene.

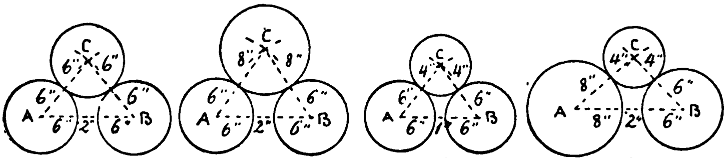
2. With proper radii, from centers A, B, and C, describe tangent circles.

Should the first two circles be secant, and the third one tangent to the other two, reduce the base of the triangle to the actual distance between centers A and B. Ex:



(1) (2) Fig. 248. (3) (4)

The first two circles may be at a distance from each other greater than their radii; but they **should not be farther** apart than the length of the diameter of the third circle. Ex:



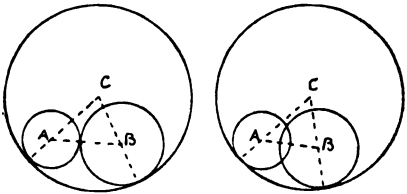
(1) (2) Fig. 249. (3) (4)

In the Book: Draw several of the foregoing problems.

SECTION 65.

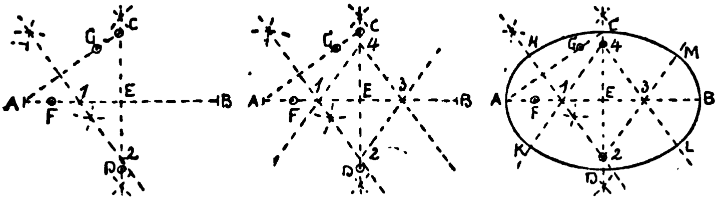
TANGENT CIRCLES. APPLICATIONS.

1. Samples of **circles tangent internally:**



(1) Fig. 250. (2)

2. With arcs of circles, to describe a curve that resembles an ellipse, the axes being given.



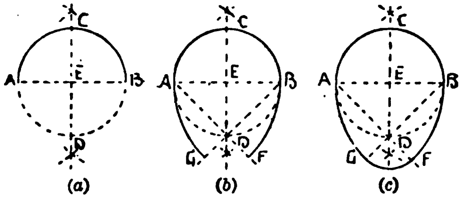
(a) (b) (c)
Fig. 251.

(*a*) Given axes A B and C D, bisecting each other in E. Connect A C. Set off E C in E F. Set off A F in C G. Bisect A G.

(*b*) Set off E 1 in E 3, and E 2 in E 4. Draw lines 2-3, 4-1, 4-3, extended.

(*c*) Radius 1 A, centers 1 and 3, describe arcs K A H and M B L. Radius 2 C, centers 2 and 4, describe arcs H C M and K D L.

3. With arcs of circles, to describe an oval.



(*a*) (*b*) (*c*)

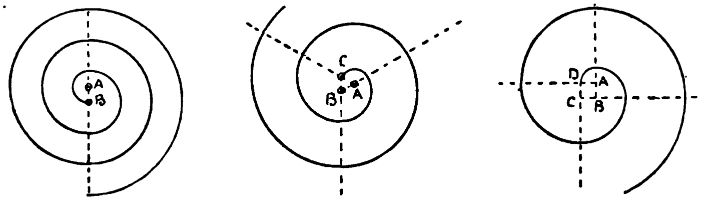
Fig. 252.

(*a*) Bisect A B. From center E, radius A E, describe circle A C B D.

(*b*) Draw indefinite lines A D F, and B D G. With radius A B, center A, describe arc B F. Same radius, center B, describe arc A G.

(*c*) Radius D G, center D, describe arc G F.

4. With arcs of circles, to describe approximately a spiral.



(*1*) (*2*) (*3*)

Fig. 253.

In the Book: Draw the foregoing or similar exercises.

—— SECTION 66. ——

DECORATION. CRESCENTS.

Horizontal bands tend to make persons, rooms, etc., appear smaller, lower. Vertical bands tend to make them appear taller, higher.

Oblique or diagonal lines give the idea of unsteadiness, and generally should be avoided, unless diagonals of an opposite slant are introduced.

When several points of attraction are needed, as in borders and in all-over patterns, these prominent points should be so arranged, and be distant enough as not to interfere with one another.

Cut two sets (different sizes) of several units in fig. 254. Follow **"General Directions,"** Section 12.

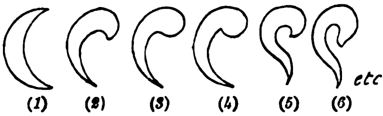


Fig. 254.

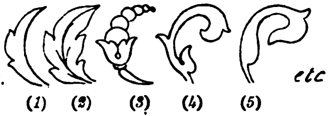


Fig. 255.

Fig. 255. Modifications of the crescent.

Combinations:

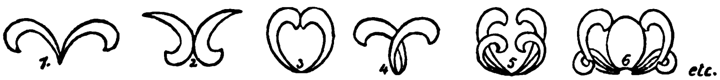


Fig. 256.

In the Book: Cut and paste a colored paper rosette, or a border.

Samples:

Rosette. Work as in Section 36.

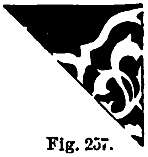


Fig. 257.

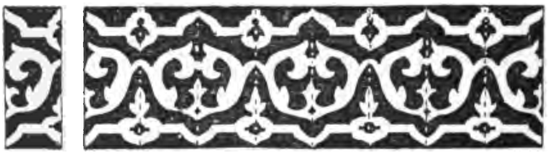

(a) (b)

Fig. 258.

Border. (*a*) Fold the paper four times, to have eight equal oblongs.

(*b*) Draw the pattern, leaving an enclosing band at the top, and another at the bottom of the paper.

—— SECTION 67. ——

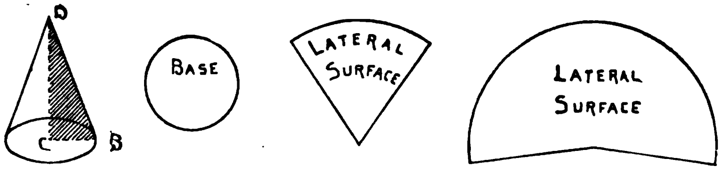
MAKING A PAPER CONE.

THE CONE.

A Cone is a solid **generated by the** revolution of a **right-angled triangle,** C B D, about the side D C, (*a*), fig. 259. The point D is the vertex, and the line D C **the axis** and altitude.

The covering of a cone consists of two pieces, cut separately.

1. A circle for its base (*b*).
2. A sector for its lateral surface; either (*c*) or (*d*).



(*a*) (*b*) (*c*) (*d*)

Fig. 259.

Make the paper model of a cone, its base and its altitude being given. Base, 1' radius; altitude, 2½'.

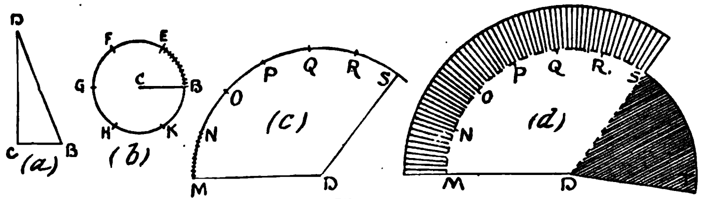


Fig. 260.

(*a*) With the radius of the base and the altitude of the cone, make a **right-angled triangle.**

(*b*) **Base.** Describe a circle, 1' radius.

Divide the circumference into sixths.

(*c*) **Lateral Surface.** With hypotenuse D B, in (*a*), as a radius, describe an arc for a sector. Draw radius D M.

The radius of the sector is equal to the hypotenuse of the right-angled triangle (*a*). The length of the arc of the sector must equal the length of the circumference of the circle forming the base of the cone.

In (*b*), with the dividers, set off upon the circumference of the base, from B to E, any number of *very small* equal divisions. Set off the same divisions from M to N, in (*c*).

Arc M N equals B E, or $\frac{1}{8}$ of the circumference of the base. Then, with a radius equal to M N, set off points O, P, Q, R, and S.*

(*d*) **Mounting.** Add sector D S T, any size. From center D, with a larger radius, describe another arc. The space between the concentric arcs is to be cut into *very small strips*.

In mounting, paste D M exactly upon D S; let it dry; then paste the small strips together, and finally the circle forming the base.

A double base may be added as in the cylinder, Section 42.

SECTION 68.

MAKING PAPER PYRAMIDS.

GENERAL METHOD.

1. Draw the base of the pyramid. Find its center.

2. Construct a right-angled triangle with the altitude of the pyramid and a line equal to the distance from the center of the base to one of its corners. Fig. 261.

3. With the hypotenuse of this triangle, describe an arc. Upon this arc set off one of the sides of the base as many times as necessary. Connect these divisions to one another and also

---

* For pupils advanced enough in arithmetic:

1. Find (by square root) the length of the hypotenuse.

2. Then, find number of degrees of the sector, thus: Multiply the length of the radius of the base by 360 degrees, and divide the product by the length of the radius of the sector. Example: Let the radius of the base be 3″; the altitude 4″; the hypotenuse will be 5″. Multiply 360 degrees by 3, the radius of the base; divide the product by 5, the radius of the sector. Ans.: The angle of the sector equals 216 degrees.

Use the protractor to mark off these 216 degrees.

to the center of the arc. This gives the lateral surface. Add the base to one of the lateral faces.

4. Add surfaces for mounting. Fold and paste.

EXERCISES.

Make the paper model of a pyramid, its base and its altitude being given.

1. **Square Pyramid:** Base, 2″ square; altitude, 2½″.

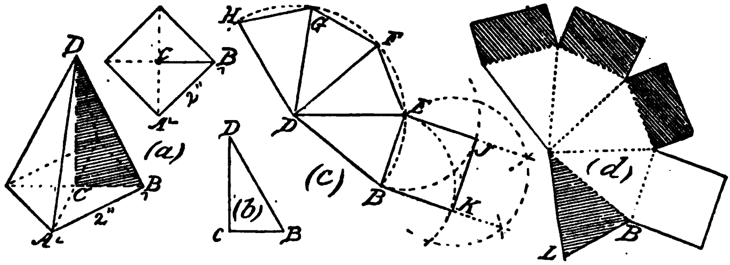


Fig. 261. Fig. 262.

Fig. 261. Oblique projection showing the right-angled triangle made by the altitude C D, and a line extending from the center of the base to one of its corners. Hypotenuse D B makes one of the ribs or edges of the pyramid.

Fig. 262. (*a*) Construct a two-inch square. Find its center.

(*b*) Construct a right-angled triangle, with the altitude D C, 2½″, and the perpendicular C B, equal to the distance from the center C to one of the corners, B, of the base.

(*c*) With hypotenuse D B, as a radius, center D, describe arc B H. From B, set off upon B H four times the side A B of the square base. Draw radii D B, D E, D F, D G, D H, and lines B E, E F, F G, and G H. Construct square base, B E J K, with ruler and triangle, or with compasses as shown in fig. 262.

(*d*) Add triangle L B, and other surfaces needed for mounting. Fold and paste.

All regular upright pyramids are worked in the same manner.

2. **Regular Hexagonal Pyramid.** Base, 1″ side; altitude, 2½″.

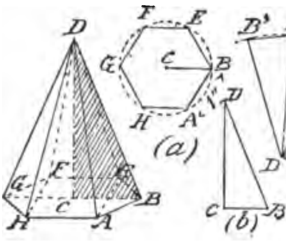


Fig. 263.

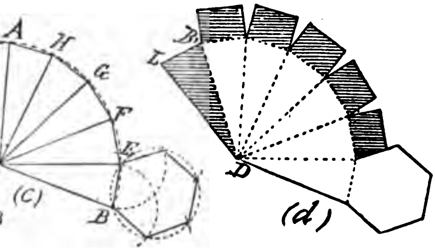


Fig. 264.

3. **Equilateral Triangular Pyramid.** Base, 2″ side; altitude, 2½″.

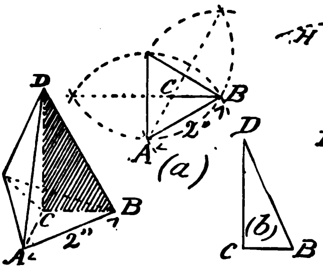


Fig. 265.

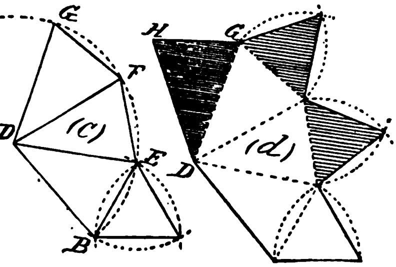


Fig. 266.

Skeleton Models. Square pyramid as a sample:

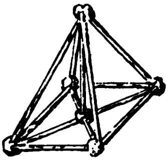


Fig. 267.

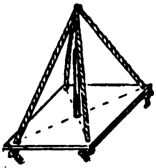


Fig. 268.

Fig. 267. **Peas and splints.**

Fig. 268. **Cardboard and twine.** To keep the edges in place, put up a splint for the altitude, or hang the model by its apex.

SECTION 69.

PROJECTIONS OF PYRAMIDS.

Free hand, with instruments, or both:

1. Draw the base and the altitude of the pyramid.
2. Connect the vertex with all the angles of the base.

Work with Models. Place them in different positions, and at different stations. Turn the sketches about, etc. Work rapidly.

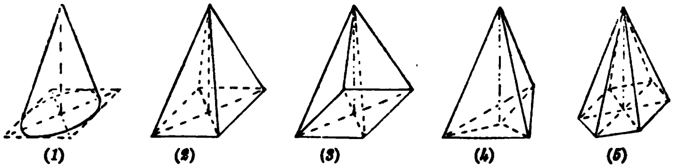


Fig. 269.

PLANS AND ELEVATIONS.

Place the cone upon your lap; move it until you see the circumference of its base, with its vertex in the center. This is the **plan;** draw it.

Now raise the model in front of your eye until its base appears as a straight line. Supposing the cone to be flat against the wall, what figure would your see? Draw it; it is the **elevation.** Ans. (1) fig. 270.

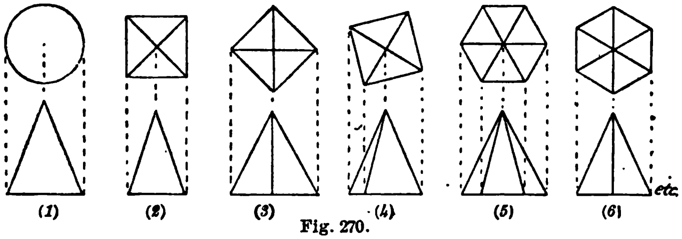


Fig. 270.

Work in the same manner, (2) (3), etc. Draw a full line for every edge that is seen, and a dotted line for each edge not seen.

In the Book: Sketch the oblique projection of any pyramid, then draw its plan and elevation.

—— SECTION 70. ——

SECTIONS OF RECTANGULAR PRISMS.

Models of the following blocks should be made of soft wood, soap, clay, etc.

Draw free hand, lightly and rapidly:—

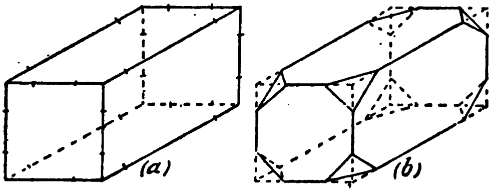


Fig. 271.

(*a*) Outlines of the original block. Determine what part of each line (edge) should be cut off from the corners.

(*b*) Connect section points.

Work in the same manner:

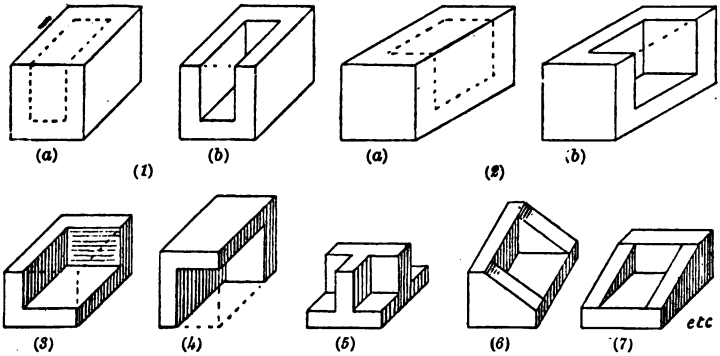


Fig. 272.

Draw the same model in other positions and at other stations. Turn the sketches around, in front of your eye.

Draw the oblique projection of the following plans and elevations:

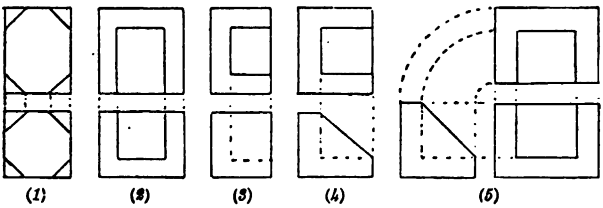


Fig. 273.

In the Book: With instruments, draw one of the sketches that you have made. Do not copy the sketches in the book unless they are drawn in other positions or at other stations.

—— SECTION 71. ——

SECTIONS OF RECTANGULAR PRISMS.

Work as in last section:

1. **Draw plans and elevations of the following figures:**

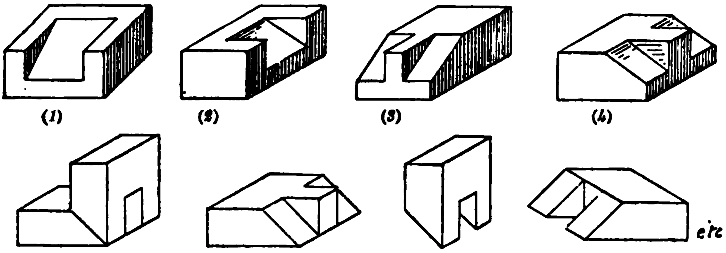


Fig. 274.

2. **Change into oblique projection:—(Any station).**

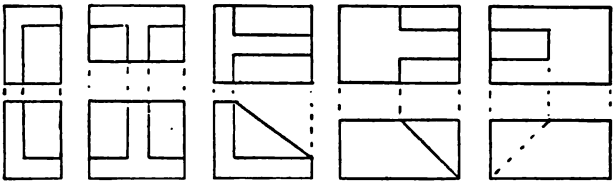


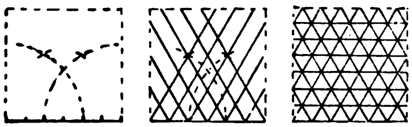
Fig. 275.

In the Book: Work as in last section.

—— SECTION 72. ——

ALL OVER PATTERNS
THE EQUILATERAL TRIANGLE.

Most of the frames for all over patterns are made of squares (Section 48) or triangles. A few are made of oblongs, rhombs, pentagons, etc.



(a) (b) (c)

Fig. 276.

(*a*) On base line, set off a number of equal divisions. At its extremities draw arcs of 60 degrees.

(*b*) From every point of

division, with ruler and triangle, draw lines making angles of 60 degrees with the base line.

(*c*) Draw horizontal lines passing through the intersections of the oblique lines. Continue drawing parallel lines until the whole space is filled with equilateral triangles.

Use the same methods as for the all over square pattern, Section 48.

FIRST METHOD.

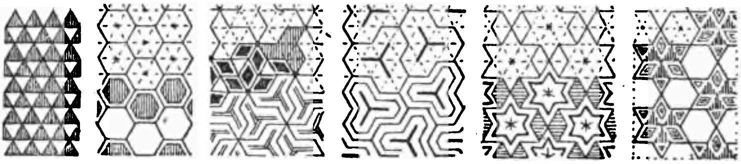

(1) (2) (3) (4) (5) (6)

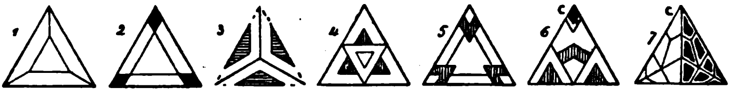
Fig. 277.

Free hand or with instruments, draw a number of small triangles, fig. 276.

Considering the intersections of the lines as points, connect these points by new lines, (1), (2), (3), etc., fig. 277.

SECOND METHOD.

Draw a number of triangles larger than those in the first method. Select a unit of design from the following, or invent one of your own *having few lines only.*



(1) (2) (3) (4) (5) (6) (7)

Fig. 278.

Units 6 and 7 are each grouped around center C. Unit 7 is taken from an Arab lattice pattern.

Half tint, color, change some of the straight lines into curves, etc. Find in magazines and periodicals other all overs on the triangular pattern.

In the Book: Draw a pattern for an oil-cloth, inlaid wood, or a mosaic.

CHAPTER VII.

SECTION 73.

SUPERPOSITION OF SOLIDS.

Models: 1. A book for a base; and

2. A rectangular prism, a cylinder, a square pyramid, and a cone, to be placed upon that base.

Use paper models already made, or else make others from clay, plaster, soap, etc.

A solid may be placed :—

1. *Upon* another. 2. *Under* another. 3. *In front* of another. 4. *Behind* another.

1. **Placing a solid upon another.**

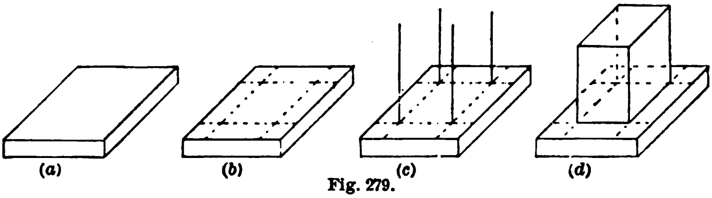


Fig. 279.

(*a*) Plinth or base. (*b*) Base and station of the prism upon that base. (*c*) and (*d*) Prism upon the plinth or base.

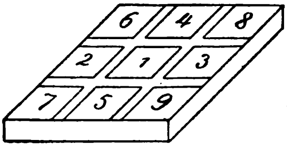


Fig. 280.

The upper solid may be moved to any place upon the plinth.

Work the other solids in the same manner. Ex.:

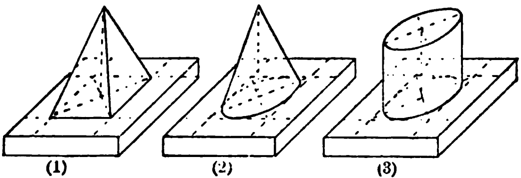


Fig. 281.

Move the other solids to other stations upon the base.

In the Book. Draw sketches similar to those in this section.

SECTION 74.

SUPERPOSITION OF SOLIDS. (Continued.)

Models: The same as in last Section 2, placing a solid under another.

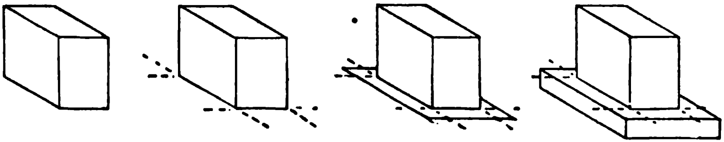

(a) (b) (c) (d)

Fig. 282.

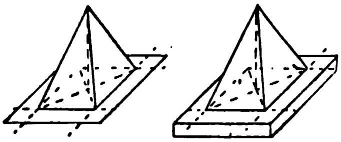

(c) (d)

Fig. 283.

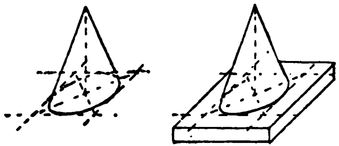

(b) (d)

Fig. 284.

Place several models upon the plinth and sketch whatever parts are seen. Ex.:

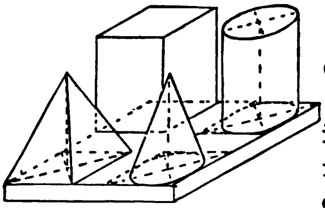


Fig. 285.

Arrange these solids differently; draw them.

In the Book: Freehand or with instruments, sketch your own arrangement of one or of several models upon a plinth or base.

SECTION 75.

GROUPS OF SOLIDS.

Models. The same as in Section 73.

3. **Placing a solid in front of another.**

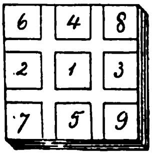


Fig. 286.

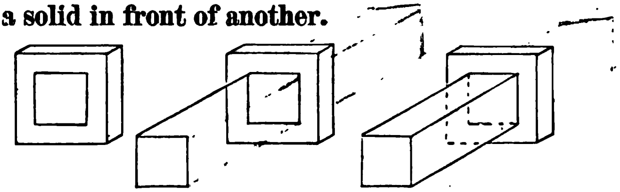

(a) (b) (c)

Fig. 287.

NOTE. **All the oblique lines** of the same sketch **must be parallel.** Substituting other solids for the square prism, work in the same manner:

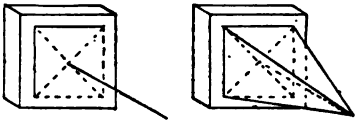

(b) (c)

Fig. 288.

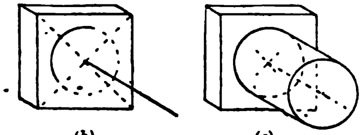

(b) (c)

Fig. 289.

NOTE. The axes of the cone and of the square pyramid follow the slant of the oblique lines of the plinth.

4. **Placing a solid behind another:**

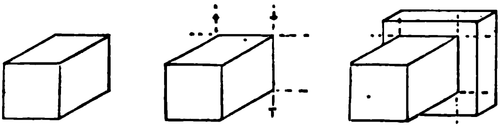

(a) (b) (c)

Fig. 290.

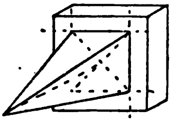


Fig. 291.

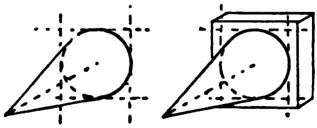


Fig. 292.

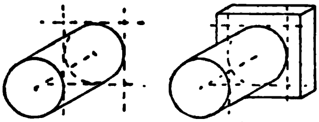


Fig. 293.

Change stations and positions; substitute one solid for another; sketch several solids upon the same base, etc. Make other combinations. Ex.:

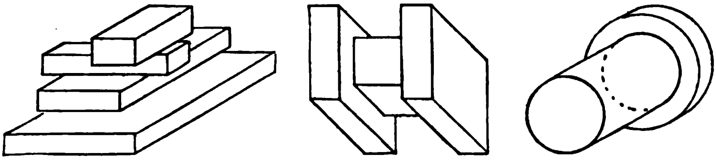

(1) (2) (3)

Fig. 294.

In the Book: From the models, make a sketch like any of the foregoing.

SECTION 76.

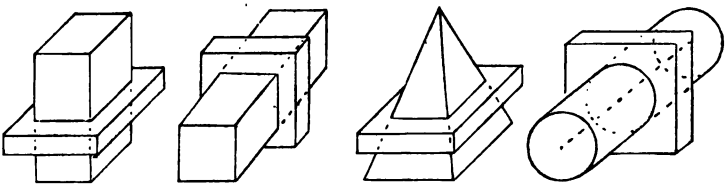
PENETRATION AND INTERSECTION OF SOLIDS.

Free hand, or with instruments:—

FIRST METHOD.

Extend the lines of the inner solid through the outer one.

Examples from figures 279, 287, 283, and 289.

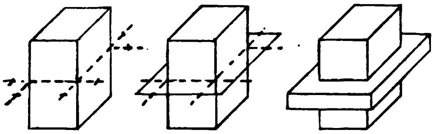


From 279. From 287. From 283. From 289.

Fig. 295.

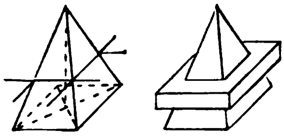
SECOND METHOD.

Drawing the inner solid first.



(a) (b) (c)

Fig. 296.



(a) (c)

Fig. 297.

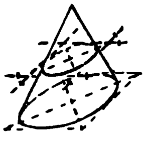
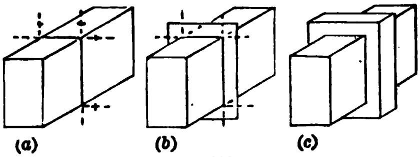


Fig. 298.



(a) (b) (c)

Fig. 299.

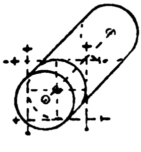


Fig. 300.

In the cone, fig. 298. (1) Draw the cone. (2) At the proper height, draw axes of upper ellipse. (3) Describe upper ellipse. (4) Work the remainder as in fig. 284.

In the Book: Sketch a few examples similar to those in this section.

SECTION 77.

OBLIQUE PROJECTION, AND WORKING DRAWINGS.

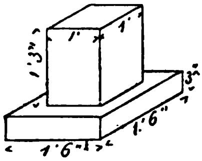


Fig. 301.

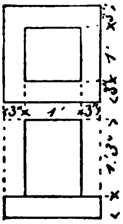
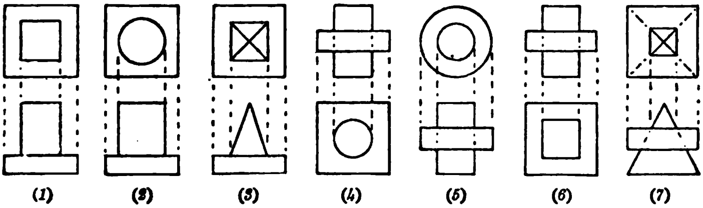


Fig. 302.

Models. Same as in the preceding sections. Draw the working drawings of fig. 301.

Answer: fig. 302. In the same manner draw the plans and elevations of figures 281, 287, 288, 285, and 294.

Placing the models at any station, sketch rapidly the oblique projection of:



(1) (2) (3) (4) (5) (6) (7)

Fig. 303.

In the Book: Sketch similar examples, using models.

SECTION 78.

DECORATION.

BORDERS. THE CROSS.

Free hand, instrumental or both :

Read "General Directions." Section 12.

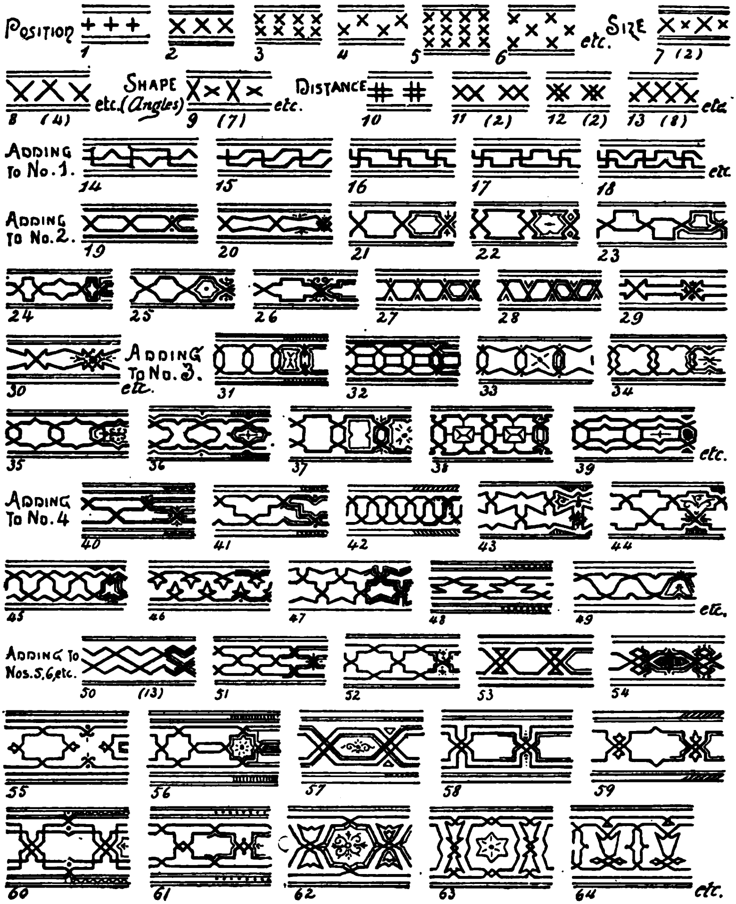


Fig. 304.

In the Book: Select two or three examples. Copy them with pen and ink or with colored crayons. Improve them by changing some of the straight lines into curves, double lining, half tinting, interlacing, adding conventional leaves, etc.

SECTION 79.

MODELS OF TRUNCATED PYRAMIDS.

Make the models of clay, soap, etc.

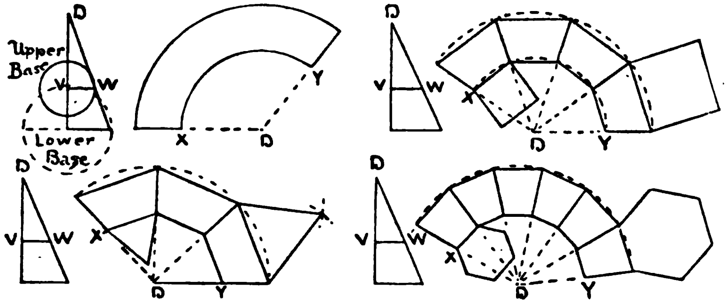


Fig. 305.

Paper Models. (1.) Draw the whole covering of the cone, or pyramid, as in Sections 67 or 68.

(2.) On generating triangle, draw section line, V W, parallel to, and at the proper distance from the base.

(3.) With D W as a radius, center D, describe arc X Y on the lateral surface.

(4.) Finish as shown fig. 305. Add inner base, etc.

DESIGN FOR A LAMP SHADE.

At home, find the dimensions of an ordinary lamp shade.

Supposing a lamp shade 5″ high, diameter of upper circle 4″, and diameter of lower circle 12″. Find the right-angled triangle with which that pyramid is developed.

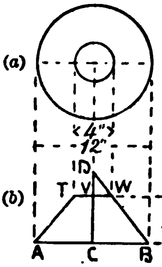


Fig. 306.

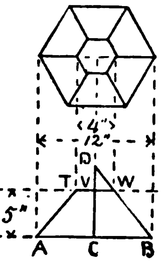


Fig. 307.

(*a*) Plan. Radii 2″ and 6″ respectively.

(*b*) Elevation A B W T. Extend B W, and C V, until these lines meet in D. Triangle C B D gives the radii D B for the lower base, and D W for the upper base of the truncated pyramid. For the remainder, see fig. 305.

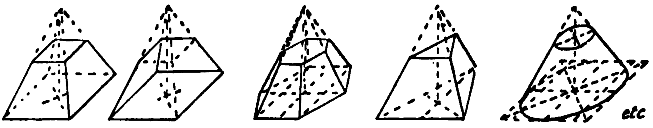
Fig. 307. Triangle for a regular hexagonal lamp shade. Same dimensions as for the cone.

Draw the geometrical divisions and ornamentation before pasting. Use colored paper, or cut the design through as for stenciling, then paste transparent colored paper inside. Add fringes, pinking, etc.

SECTION 80.

PROJECTIONS OF TRUNCATED PYRAMIDS.

Use models. Free hand, or with instruments.

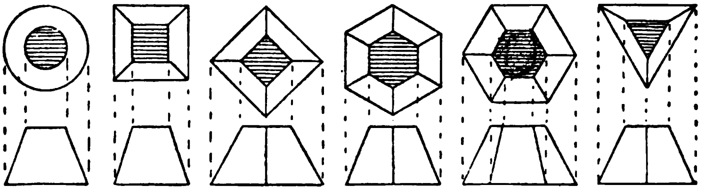


(1) (2) (3) Fig. 308. (4) (5)

1. Draw the **oblique projection** of the whole pyramid.
2. Work the upper base of the truncated pyramid as in (*a*) fig. 297, and in fig. 298.

Draw the **plans and elevations** of examples (1), (3), (4) and (5) in fig. 308.

Draw the **oblique projection** of the following:



(1) (2) (3) (4) (5) (6)
Fig. 309.

In the Book: Draw the oblique projection, and the plan and elevation of any truncated pyramid.

SECTION 81.

DECORATION. VASES.

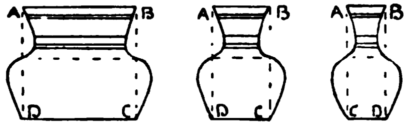
At home, or elsewhere, examine vases having simple outlines; bring them to school; tell about the materials used in their construction, their special uses. Find all the facts about their manufacture, by reading books, enquiring, etc.

Measure the heights and the widths of vases, and the principal divisions of these dimensions.

Observe closely the shapes of the different curves; their bases and altitudes.

Take no notice of the ornaments of vases until you have analyzed their general outlines.

Compare these three vases:—Find how many times A B is contained in A D.



(1) Height, 1. Width, 1.
(2) Height, 1. Width, ½.
(3) Height, 1. Width, ⅓.

Fig. 310.

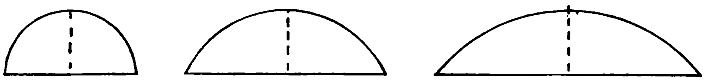
With curves alike, what causes the last vase to look more pleasing than the other two?

Rule. The simpler the proportion, and *the more easily detected* by the eye, *the less pleasing the effect.*

The proportion 1 to 3 is not the best, yet, 3 to 7, 5 to 13, etc., would be more pleasing still.

The same rule applies to a curve:

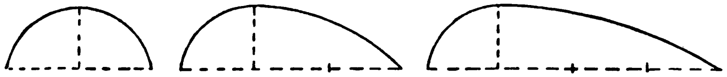
1. In regard to the proportion between the height of its altitude and the length of its base:



(1) Altitude, 1. Base, 2.
(2) Altitude, 1. Base, 3.
(3) Altitude, 1. Base, 4.

Fig. 311.

2. In regard to the place of the greatest altitude upon the base:



1 to 2.
1 to 3.
1 to 4.

Fig. 312.

3. In regard to the division of the whole base in a reversed curve:

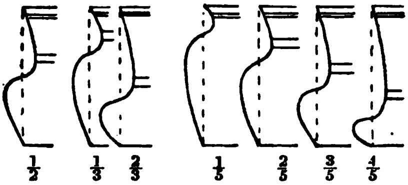


Fig. 313.

Notice that great differences in size, as 1/5, 4/5, etc. do not always produce the best curves.

The pupil should select a graceful curve, and make, with it, upon his slate or paper, a vase at least five inches high, (two feet upon the blackboard.)

Draw the left side of the vase, the rectangle; and then the right side which should be as nearly alike to the left as possible. Hold the sketch at a distance, etc.

When this sketch is satisfactory to the teacher, the pupil may be allowed to add ornaments.

In circular vases, the lines of the ornaments are closer at the edges than at the center.

In the Book: Draw the elevation of a vase; take any of the following curves, or sketch those of a *real* vase.

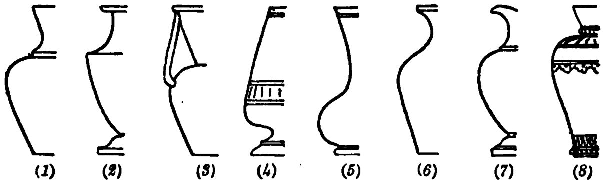


Fig. 314.

SECTION 82.

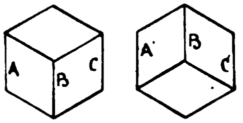
ISOMETRIC PROJECTION.

Model: a cube.

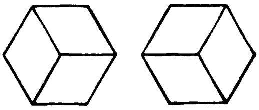
1. With the index finger and the thumb, take hold of two of the farthest opposite corners of a cube.

2. Hold these corners up and down; place the model in front of your eye; then turn it until three of its faces appear equal.

3. The drawing of this cube as you see it now is called an *isometric projection*, fig. 315. Notice that lines A, B, and C are drawn as vertical lines, though the edges they represent are really oblique lines. Hold up a pencil, slanting it forward or backward, at a distance in front of your eye; it will appear vertical: it is the same with some of the edges of the cube.



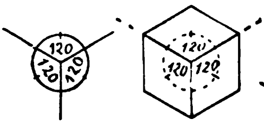
(a) (b)
Fig. 315.



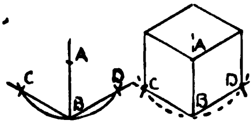
(a) (b)
Fig. 316.

4. Repeating the same operation with the farthest corners of the cube placed right and left, will give fig. 316.

Drawing an Isometric Cube.*



(a). Fig. 317. (b).



(a). Fig. 318. (b).

(*a*) Begin with the solid right-angled central corner of the cube, making three apparent angles of 120 degrees each. Then make the lines of the required length.

(*b*) Draw rhombs.

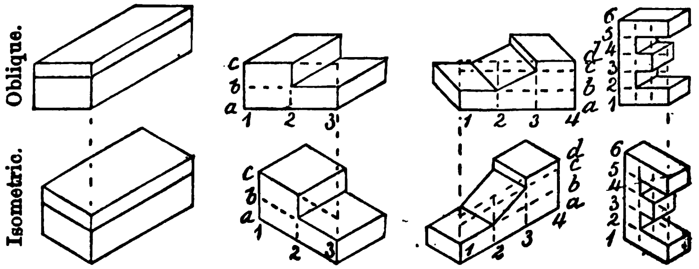
Figure 318. (*a*) Draw vertical line A B. From center A, describe an arc in B C D. With the same radius, center B, describe arcs in C and in D. Draw lines B C, and B D, extended.

(*b*) Make each line of the required length, construct rhombs.

---

* We are all well aware that lines in the isometric projection are foreshortened and that a special rule should be given to meet this case, but for the sake of simplicity, the length of every line has been given in full; this being approximately near enough for all practical purposes as intended in this course.

Changing *oblique into isometric* projection.



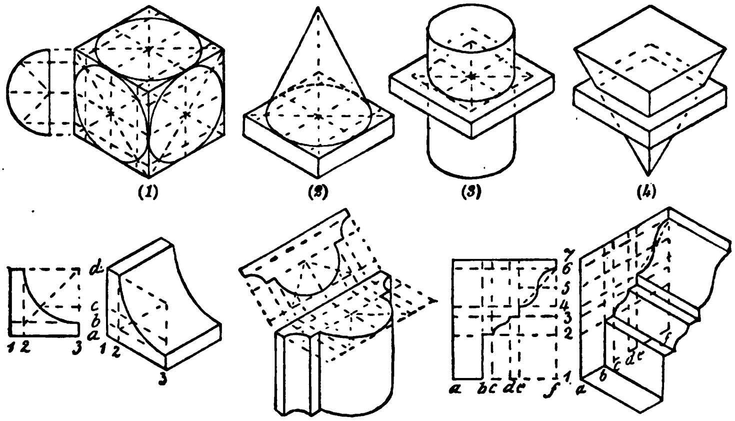
(1) (2) Fig. 319. (3) (4)

In the Book: Draw the plan and elevation, the oblique projection, and the isometric projection, of one of these or similar examples.

—— SECTION 83. ——

ISOMETRIC PROJECTION. THE CIRCLE, ETC.

Do not draw *all* the following examples, but be able to draw them *all*.



(5) (6) (7)
Fig. 320.

In the Book. Draw the plan and elevation, the oblique projection, and the isometric projection of any of the foregoing or similar figures.

SECTION 84.

DIAPER PATTERN. THE CIRCLE.

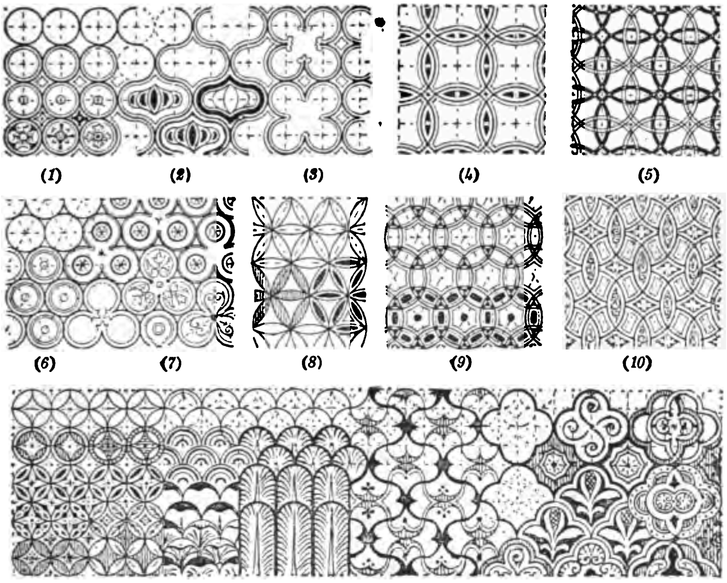
Models: Colored circles of two or three different sizes.

Work according to "General Directions," Section 12.

The following patterns are arranged on the square and on the triangular plan; they are:—

(*a*) Tangent in numbers (1), (2), (3), (6), (7), fig. 321.

(*b*) Secant in numbers (4), (5), (8), etc.



(1) (2) (3) (4) (5)

(6) (7) (8) (9) (10)

(11) (12) (13) (14) (15) (16) (17)

Fig. 321.

Spacing the circles and connecting them by lines would result in a number of new patterns.

Suppressing part of the circles gives the scale and feather patterns (13), the double ogee (14), and other variations, (2), (3), (7), (15) (16), (17).

In the Book: Make a design for a floor decoration, or a stained glass window, using circles as the unit.

Add leafage, and other ornaments; color, etc.

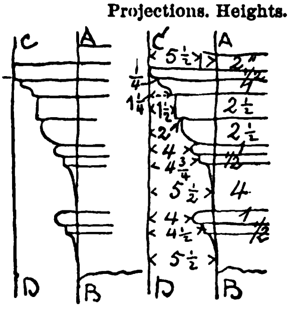
CHAPTER VIII.

SECTION 85.

ELEVATIONS. ROUGH SKETCH.

Buildings, articles of furniture, etc., are solids, and are generally ornamented with mouldings.

Rough sketch :



(a) Fig. 314. (b)

(*a*) Draw line A B, representing the edge of the object without mouldings. On a large scale, make a rough sketch of the mouldings. To see them better, look at the corner of the object. It does not matter if you have the *true* proportions between the different parts or not, so long as each moulding can be recognized easily. Add line C D, and horizontal lines.

Measuring. (*b*) With ruler and triangle, find the heights of all the mouldings. Mark these heights on the right of A B.

To find the projections, place a vertical ruler, C D, against the most projecting moulding, and measure the distance of each moulding, from the ruler, C D. Write dimensions on the left of A B.

Work incised objects by a similar process.

It takes some ingenuity to do this exercise properly, but it is well worth trying.

In the Book : Do not copy fig. 314, but select a real pedestal, cornice, post, mantel, article of furniture, etc. (not too difficult), and make a rough sketch of its elevation. Write dimensions.

SECTION 86.

ELEVATIONS. SCALE.

In a *full size scale* the lines on the drawing are as long as the corresponding lines on the object.

In an *enlarged scale* the lines on the drawing may be 2, 3, 4, etc., times their real lengths on the object.

In a *reduced scale* the lines on the drawing may be $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc., of their real lengths on the object.

In a $\frac{1}{2}$ scale, 6″ represents 1′.
A $\frac{1}{3}$ scale = 4″ to 1′.
A $\frac{1}{4}$ scale = 3″ to 1′.
A $\frac{1}{6}$ scale = 2″ to 1′.
A $\frac{1}{8}$ scale = $1\frac{1}{2}$″ to 1′.
A $\frac{1}{12}$ scale = 1″ to 1′.
A $\frac{1}{24}$ scale = $\frac{1}{2}$″ to 1′.
A $\frac{1}{48}$ scale = $\frac{1}{4}$″ to 1′.
A $\frac{1}{96}$ scale = $\frac{1}{8}$″ to 1′, etc.

All the scales in which the foot is a unit have one of these divisions subdivided into twelfths, and are used exactly as the 1″ to 1′ scale, Sections 25 and 26.

Rough sketch of fig. 314 drawn to a scale.

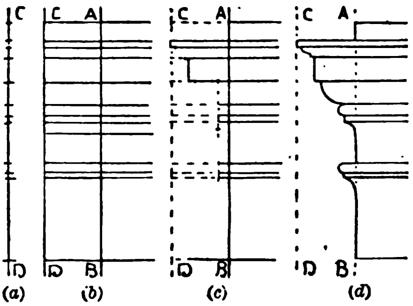


Fig. 315.

Before attempting to draw anything, find the size of the paper, and of the object, allow for a proper margin all around the drawing; select the most suitable scale; then:

(*a*) Draw line C D, and upon it mark the heights of the mouldings.

(*b*) Draw horizontal lines through points of division on C D.

(*c*) From line C D, draw the distances of the straight-faced mouldings (fillets, plinths, etc.)

(*d*) Add the curved mouldings.

Use compasses whenever possible; otherwise, draw the small curves free hand. Ink or line in. Work in the same manner the rough sketch you made already.

NOTE. The whole class may have the same subject, or each pupil a different one.

SECTION 87.

ABSTRACT CURVES. SPIRALS.

Models: With iron or copper wire, make several pair of spirals, each pair of a different size and shape. If wire is not at hand, cut stiff paper as in fig. 316.

EXERCISES.

1. Arrange the spirals as in fig. 317. Find other combinations and draw them rapidly.

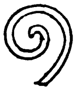


Fig. 316.

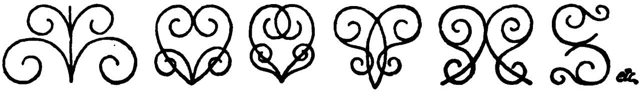


Fig. 317.

Give special attention: (1) To gracefulness of curvature. (2) To the tangential union of lines. (3) To the balancing of lines.

Borders:

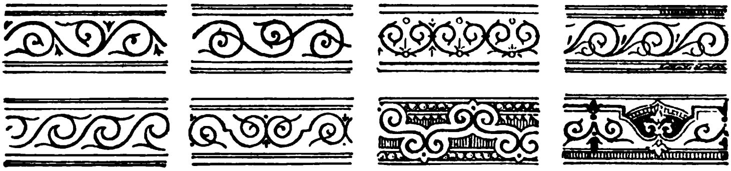


Fig. 318.

2. Draw the left side, then the right side of:

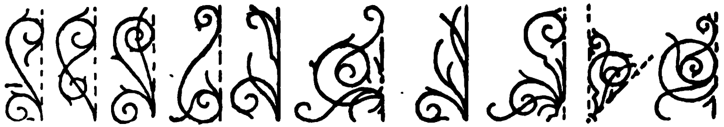


Fig. 319.

These spirals are used in the main or construction lines of designs for scrolls, panels, metal crestings, and other works. They are not regarded as enclosing forms.

Add double lines, conventional leaves, etc.

On a large scale, draw one of the examples in figs. 318 and 319. Add double lines, crochets (side ornaments which are like thorns on a rose twig), etc.

Use the arm movement. Draw boldly and rapidly.

—— SECTION 88. ——

PLANS OF HOUSES. ROUGH SKETCH.

NOTE 1. The aim in teaching plans and elevations is not to train pupils to become architects, but to enable them to read and draw general working drawings, such as are published daily, even in newspapers and magazines.

NOTE 2. Houses and their details have been selected, because they are more readily at hand, and are easier to draw than machines and their complicated parts.

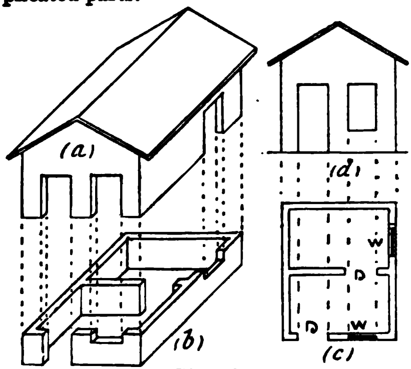


Fig. 320.

(*a*) Oblique projection of the house. The building is supposed to be cut through horizontally a little above the window sills, and its upper part taken off.

(*b*) Lower part of section showing the thickness of the walls, places of the doors, windows, etc.

(*c*) Plan of first story; D, D, doors; W, W, windows.

(*d*) Front elevation.

A house may have:—

1. One, or several *elevations* called: front, rear, right side, left side, north, south, east, west elevation; or elevation on such or such street, etc.

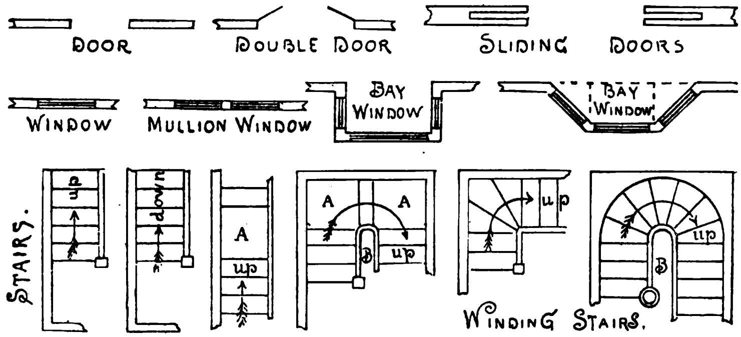
2. One, or several *plans* called: basement, first (second, third, etc.) story, attic, roof.

3. One, or the several *vertical sections:* a **longitudinal section** represents the interior of the house as it would appear after being cut vertically from front to rear, and one-half of the building removed. In a **cross section,** the house is supposed to be cut vertically from the left to the right. The front part being removed, the other part shows an elevation of the interior of the house.

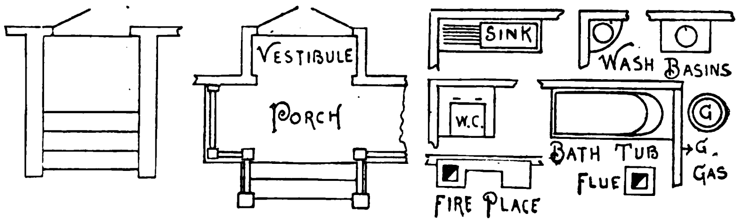
Plans of the different stories are really horizontal sections.

Details are parts of a drawing, usually full size, or on a large scale, for the use of the workman.

Parts of a Dwelling House:



A, A, A, landings; B, B, stair wells.



Steps and Landing.

Fig. 321.

Make a large free hand sketch of the plan of your school house, or, of a private house.

If too large, draw only the principal parts of the building.

Draw:—(1) The general outlines of the house. (2) The thickness of the outer walls. (3) The partitions, rooms, halls, closets, stairs, porches, outside steps. (4) The doors, windows, fire-places, sinks, etc.

Do not rule. *Do not measure.* Draw the exact number of outside steps.

In the sketch of the house, lines representing stairs five or six feet from the floor are dotted; omit these dotted lines entirely, if they interfere with closets, doors, etc., under the stairs.

Write the names of the rooms: Hall, Parlor, Bedroom, Closet, etc.

Do not include in your sketch any piece of movable furniture.

——— SECTION 89 and 90. ———

MEASURING THE DIFFERENT PARTS OF A HOUSE.

Having in hand the rough plan of the house sketched in last lesson.

Measure, and write at the proper places:

(1) The lengths of the outer lines of the house.

(2) The thickness of walls and partitions.

(3) The size of rooms, closets, halls and stairs.

(4) The size of doors and windows, and their distances from corners or other points.

(5) The dimensions of porches, steps, fire-places, sinks, wash basins, etc., and their distances from other points.

Remember:

1. To measure the *real* sizes of the walls, *without mouldings.*

2. That the opening for a door is just the width of that door.

3. That the width of a window, equals the width of its sash.

4. To use two rulers and the protractor to find the angles made by the walls of a bay window.
5. To count the number of steps, and find the size of their treads.

Measure, do not guess.

—— SECTIONS 91 and 92. ——

DRAWING THE ROUGH SKETCH TO A SCALE.

1. Find the best scale to use by comparing the size of the building with that of your paper.
2. Leave an ample margin all around your plan.
3. Draw the outlines of the outside walls to a scale.
4. Add the thickness of the walls. On your paper do not give different widths to walls of the same thickness.
5. Draw partitions for rooms, halls, closets and staircases.
6. Add porches, steps, fire-places, sinks, etc.,
7. Add doors and windows.

No free hand lines. **Do not guess.**

Use scale, ruler and triangle.

—— SECTIONS 93 AND 94. ——

Turn the plan so that the *front* of the house *will face* the *lower edge* of the paper.

1. **Lettering.** *Print* the name and the dimensions of each room, porch, etc., in the center of the space alloted to it.

Use *small* letters and figures of the simplest kind. Do not **slant them.** Ex:

Parlor.

14′ 8″ x 18′ 9″.

Print in the lower margin:

PLAN OF COTTAGE, NO............ ....ST.

Or should the house have several stories:

PLAN OF FIRST STORY

Of House, No.......... ....St.

Print in the lower margin:

Scale:............ Name of Pupil,.. ....

NAME OF SCHOOL.

2. Either line in, or ink the drawing.

Inking. Use a drawing pen. Do not fill it too much, or let the ink dry in the blade point. If the ink refuses to flow, stroke the pen point on a bit of soft paper, rag, etc. Wipe often the ruler and the outside of the blades of the pen, to keep them dry, thus preventing the ink running down and blotting the paper.

Always try the pen upon a piece of paper, before inking a line on the drawing. Ink the curved lines before the straight ones.

Lines are of four kinds:—

————————	— — — — —	....	—.—.—.—
1. Full.	2. Broken.	3. Dotted.	4. Broken and dotted.

In sizes, each is either fine, medium, or heavy.

Before trying to ink your plan. practice until you are able to ink tolerably well.

—— SECTION 95. ——

LIMITATIONS IN DESIGNING.

The same design must be modified to suit different *materials* and the *manner of working* them.

Make your drawing slender or coarse according to its being intended:—

1. For printed or colored flat designs, as wall papers, fresco work, stenciling, printed goods, illustrations, lithographic work, window shades, and other flat surfaces.
2. For carving in wood, plaster, stone, and other half relief work.
3. For cast, pressed, and embossed work, in clay, leather, tin, zinc, sheet iron, brass, papier mache, etc.
4. For turned and sawed work: brackets, handles, vases, scrolls, etc.
5. For incised designs, cut into stone, metal, glass, etc.

Another limitation is the place the ornament is to occupy.

1. Often a decoration for a wall will not answer for a floor.
2. Decoration to be seen at a distance, in an elevated position, or in a dim light, must have coarser lines and fewer details than if it were to be seen nearer or in a bright light.

Exercises. 1. Taking as a unit any form in Section 87, and ornamenting it, make several rough freehand sketches, showing how you would make that same design if the materials were (*a*) Paper, (*b*) Wood, (*c*) Metal, (*d*) Marble or stone, (*e*) Stucco.

2. After school hours, pencil in hand, find and make sketches of other units. Notice how they are treated on account of material, the manner of working them, and the places they occupy. Draw the pattern to a scale. Give the height in feet and inches.

—— SECTION 96. ——

DESIGNS FOR INVITATIONS, ETC.

Make a design for one of the following subjects:—

1. **An Illustrated Invitation:** (*a*) To a lunch, tea, dinner party. (*b*) To a club party; boating, lawn tennis, and other out-of-door entertainments.

2. **An Illustrated Programme:** For musical and literary entertainments; for graduating exercises; for a banquet, an anniversary, etc.; a bill of fare.

3. **Compliments of the Season:** Christmas, Easter, Birthday, etc.

4. **A Book Mark,** to accompany the donation of a book to a friend.

Print in full the invitation or programme, using quaint letters, monograms, etc. Do not draw anything foreign to your subject. Make everything fit the occasion.

The illustrations may be traced or sketched in colors, pen and ink, etc.

Find the most approved size and shape for your design.

Procure a box, some envelopes, or a scrap book, in which to preserve clippings from art, illustrated, and daily papers. You are sure to find a great deal of use for such a collection.

CHAPTER IX.

APPENDIX.

SHADING.
SKETCHING FROM NATURAL FORMS.

SECTION 97.

SHADING.

In Industrial Drawing, the light is supposed to come over the left shoulder, striking, at an apparent angle of forty-five degrees, the vertical and horizontal edges and faces of solids.

Thus, the front, upper, and left faces of a cube, (*a*) fig. 323, are said to be **in the light**; the lower and right faces, **in the shade**, (*f*), fig. 324.

Light and shade appear to vary with the distance. The farther the object is, the less bright the light, and the less dark the shade. This, with the apparently reduced size of distant bodies, enables us to guess at the distance of objects.

Several kinds of lines are used to express these different degrees of light and shade.

Exercises. Pen and Ink, or a very soft pencil:

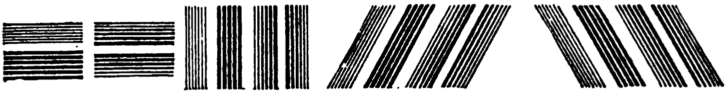


Fig. 322.

Rules for Shading. 1. Use the arm movement.

2. Draw the lines as nearly parallel as you can. Practice until you find the right kind of pressure to give your pen or pencil, according to the shade you wish to make.

3. For pen and ink work, hold your pen so that the two blades of its point will bear equally upon the paper. Hold the penholder in the direction the line is to take.

4. A strong shade is produced by coarse, dark, close lines, *vice versa* for a light shade. Do not allow your pen to become nearly dry, if you wish to have an even shade.

Straight lines are used for flat surfaces; lines more or less curved, for round or warped surfaces.

6. The difference in light is produced by drawing very *fine* and *faint* lines at the farther end of the lighted surface, (*a*), fig. 323; this difference should never amount to a shade.

7. The farther edge of a shaded surface *must not* be made darker than the next line of the shade, (*c*), (*d*), (*f*), fig. 324.

8. Do not draw zig-zag lines for smooth surfaces.

9. Draw very light lines for the edges in the light. Omit drawing any line at all when the shade lines show sufficiently the edges of the solid.

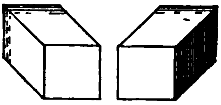

(*a*) (*b*)

Fig. 323.

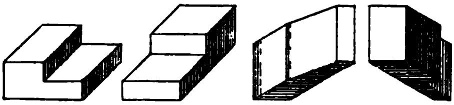

(*c*) (*d*) (*e*) (*f*)

Fig. 324.

In the Book: Draw the foregoing or similar examples.

—— SECTION 98. ——

SHADING. CYLINDERS AND CYLINDRICAL FORMS.

1. Have a cylinder, or make one by rolling and pasting a piece of thick white or yellowish paper. The bases are not necessary.

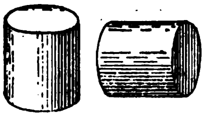
2. Place the cylinder in positions and at stations shown in fig. 325, letting the light strike the solid as in the cube, Section 97.

3. **Notice** that the darkest shade is not at the edge of the cylinder but close to it. The same applies to the light; the

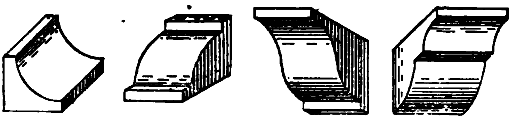
brightest streak of light is not at the edge of the cylinder, but close to it; hence, the necessity of drawing a few faint lines in order to make a difference in the light.

Do not draw dark lines on the lighted surface of the solid.

Rapidly, free hand, copy the following:

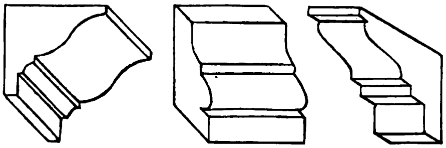


(a) (b)
Fig. 325.



(a) (b) (c) (d)
Fig. 326.

In the Book: Free hand; sketch and shade rapidly:



(1) (2) (3)
Fig. 327.

—— SECTION 99. ——

SHADING. PYRAMIDS AND SPHERE.

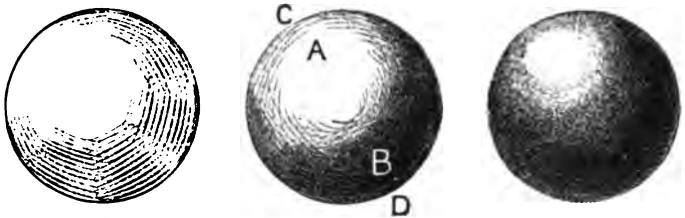
The faces of a cone or a pyramid are shaded like those of a cylinder or a prism, except that the shading lines of the cone or pyramid converge towards the vertices of these solids.

A **sphere** is represented by a circle. Shade the sphere in order to distinguish it from the circle.

In (*b*) fig. 328. A should be the brightest point and B the darkest. The surface near the outline of the sphere should be less bright at C than at A, and less dark at D than at B.

Avoid dark shading: a light touch looks better than a heavy one.

Draw several times:



(a) (b) (c)

Fig. 328.

In the Book: Shade a sphere.

—— SECTION 100. ——

DISTANCE. COMPARATIVE LENGTHS.

Repeat the drills in this and in the next two sections, a few minutes every day, until you can guess dimensions pretty accurately.

To the Teacher. (1.) Cut a number of slips of paper 1 inch by 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 16, 18, 20, 21, 24, etc. inches respectively.

(2.) Write the proper length on the back of each slip.

(3.) Hang two or more of these slips, in such a way as to conceal the lengths marked on the backs.

(4.) Call the shortest slips A; another B; etc.

(5.) Let the pupils guess and write the number of times A is contained in B, in C, etc. Then, tell them the lengths of the slips.

(6.) Repeat the same exercise with:

(*a*) Horizontal lines.

(*b*) Horizontal and vertical lines.

(*c*) Horizontal and oblique lines.

(*d*) Vertical and oblique lines.

(*e*) Oblique lines running in different directions.

In the Book: Draw, free hand, a cylindrical or a conical object; as, tin cup, collar box, pencil, roller, tumbler, drum, tea-pot, pan, moulding, etc.

Guess the comparative height and width of that object.

Aim not at perfect lines, but to give, with a few rough strokes, a fair idea of the object sketched.

Samples:

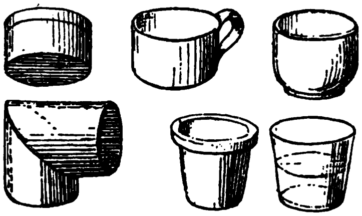


Fig. 329.

SECTION 101.

DIRECTION. ANGLES.

Free hand. No instruments.

1. Draw right angles in eight different positions:

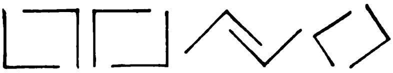


Fig. 330.

2. Draw angles of forty-five degrees, in eight different positions:

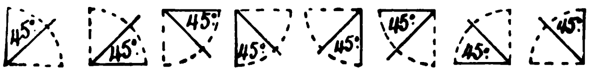
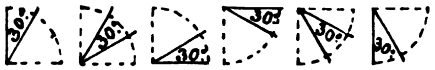


Fig. 331.

3. Draw angles of thirty degrees, in twelve different positions:



Find the others.

Fig. 332.

4. Draw angles of sixty degrees in twelve different positions:

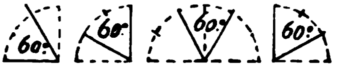


Fig. 333.

Find the others.

Draw in several positions:

5. Angles of 135, 120 and 150 degrees.
6. Draw angles of 15, 10 and 5 degrees.

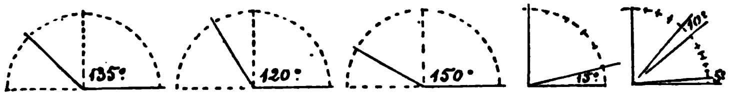


Fig. 334.

Application. Models: splints; ivy, maple, etc., leaves.

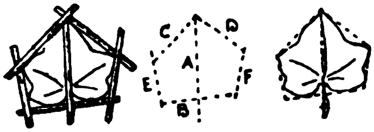


Fig. 335

(*a*) Place a leaf flat upon the desk; arrange splints all around it and one splint through the center.

(*b*) Draw A; then, in succession, B, C, D, E, and F, observing the angles the splints make, and how many times and parts of a time the smallest line is contained into the others.

(*c*) Sketch the real curves, and, *a few* of the principal veins.

In the same manner, work the leaves of other plants.

In the Book: Press a natural leaf, when dry, paste it in the book. Block it in with straight lines. Under this, enlarge or reduce proportionally the blocking in lines, and, within these, sketch the natural leaf.

—— SECTION 102. ——

DIRECTION AND DISTANCE. TRIANGLES.

To the teacher, (1.) Cut equilateral, isosceles, and scalene triangles having sides of the following lengths:—4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 21, 24, etc. inches respectively.

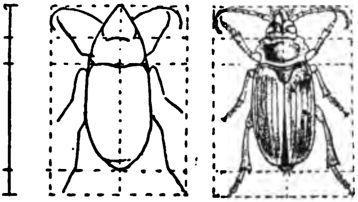
(2.) On the back of each triangle write the number of inches of each of its sides; and the number of degrees of each of its angles. (Use protractor).

(3.) Draw a coarse 4″ line upon the face of the triangle.

(4.) Let the pupils draw each triangle in the position it is placed at the board, giving the number of degrees of each angle, and the number (and fractions) of times the 4″ line is contained in each side of the triangle.

(5.) Then, tell the dimensions.

Applications: 1. Broad-neck Borer:



(a) (b) Fig. 336. (c)

(a) Draw height, and divide it according to the vertical lengths of the different parts of the insect.

(b) Draw widths in proportion to the vertical lengths. Block in.

(c) Draw the real outlines of the insect. Erase operation lines. Line in.

2. White-lined Sphinx Moth:

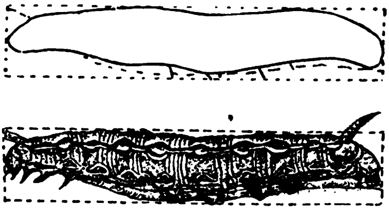
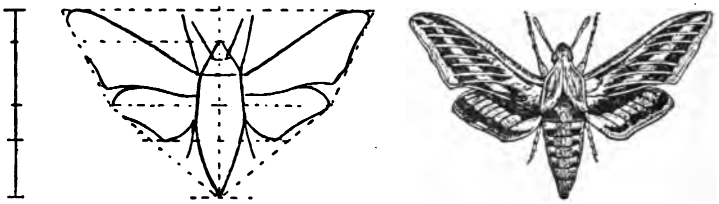


Fig. 337. (Caterpillar.)



(a) (b) Fig. 338. (c) (Moth.)

In the Book: Sketch one or several insects, from the model, if possible.

SECTION 103.

MECHANICAL DEVICES.

There is a number of mechanical devices to ascertain the comparative lengths, and the direction of lines.

The following are frequently used:—

The pencil in hand measurement.

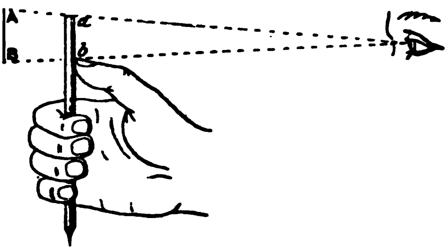


Fig. 339.

(1.) Shut one eye; steady yourself against the back of your seat.

(2.) Always hold the pencil at **full arm's length** and **parallel** to your face.

(3.) Let *a*, the end of the pencil, cover, exactly *A* on line A B, seen at a distance.

(4.) Move your thumb up or down the pencil, until at *b*, it covers point B, on distant line A B.

(5.) Keeping your hand always at the same distance from your eye, find out how many times this line *a b* is contained in the other lines of the same object.

(6.) Remember that these measurements are to ascertain the *proportion only* of objects, and *not their real size.*

2. What the pencil-in-hand measurement is for the comparative lengths of lines, the following instrument is for angles:

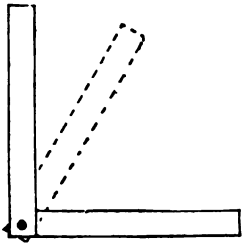


Fig. 340.

Make it with two strips of cardboard fastened together at one end.

Use it as the pencil-in-hand device. Sit erect, one eye closed, hold the strips at arm's length, keeping them always parallel with your face. Open or close the slips, to make this paper angle fit the angle seen at a distance.

Draw angles, triangles and other polygons upon the blackboard, and measure them. Use models of Section 102.

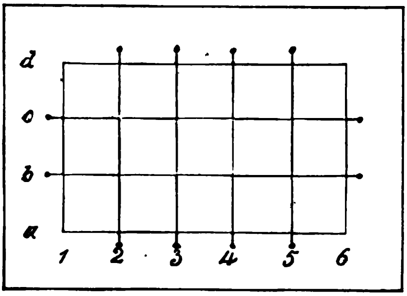


Fig. 341.

3. The Diascope. Through the center of a 5″ x 7″ piece of cardboard, cut an oblong 3″ x 5″. Divide this opening into square inches, by vertical and horizontal intersecting threads, fig. 341.

Using this card as directed for the pencil in hand device, imagine that the object seen through the diascope is only drawn or painted upon it.

Sketch that view in an oblong divided in the same manner as the diascope.

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